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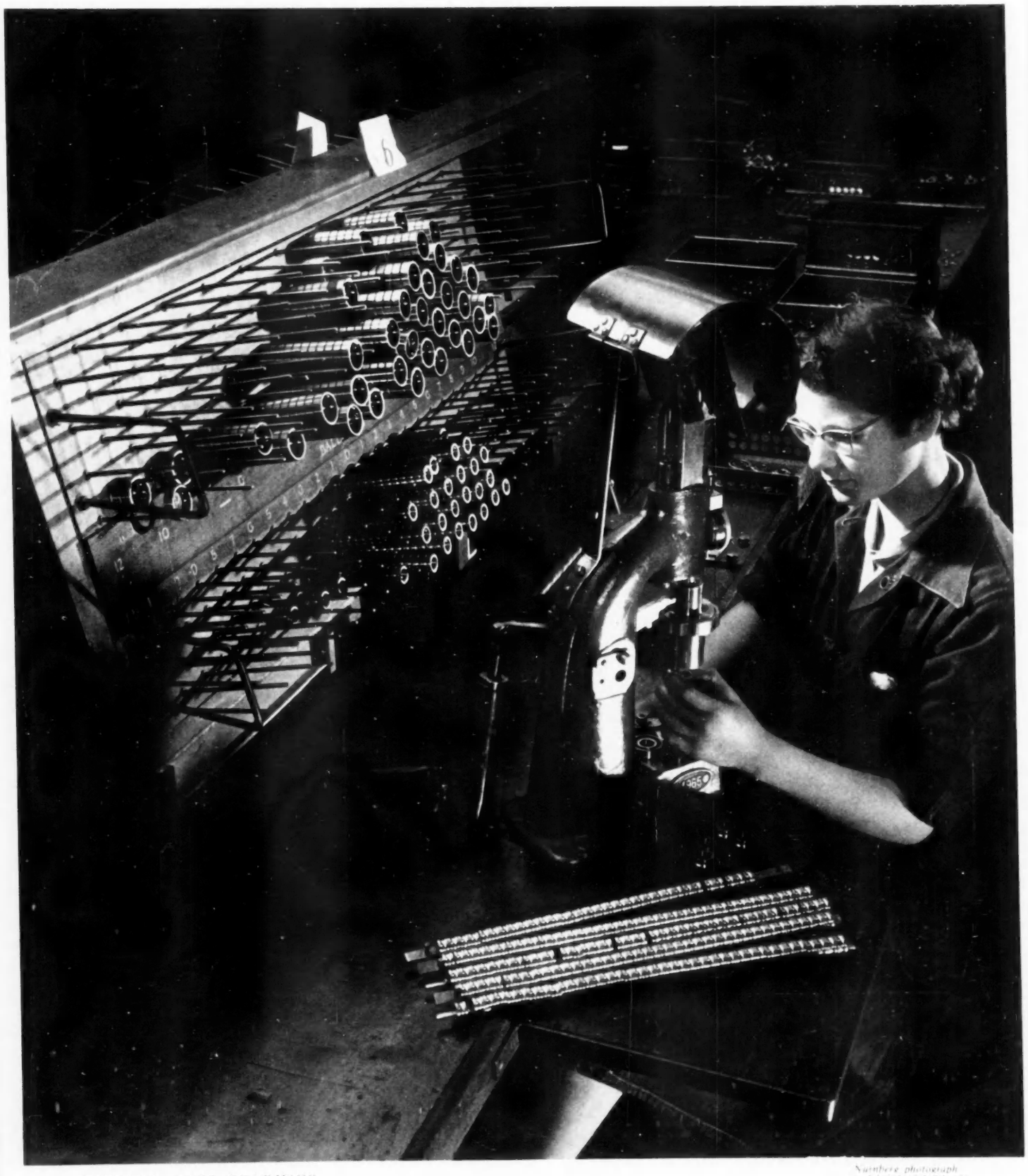

GRADING BALL BEARINGS

Numbered photographs are ENGINEERING

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THE CALL OF THE WEST

LAST year Britain lost just over 300 professional engineers to Canada and the United States. This figure may not sound very large, but it was equivalent to 8 per cent. of the increase in membership of the Institutions of Mechanical, Electrical, and Production Engineers and the Royal Aeronautical Society. The rate at which physicists and chemists went west, according to the last annual report of the Advisory Council on Scientific Policy, increased during the years 1950 to 1956, but engineers went at a more steady rate.

Not all this emigration is dead loss, for a proportion of the emigrants may well return to this country over the next few years with a broader outlook and valuable experience; and no one would disagree with the opinion expressed by Sir Arthur Whitaker, in his presidential address to the Institution of Civil Engineers, about the value for a young engineer of work overseas. Nevertheless, because of our own desperate shortage of scientific and engineering manpower, any tendency for the increasing amount of public funds being devoted to scientific and technical education to be lost to the nation, because a growing proportion of those who benefit from them make no return to the national economy, would be a cause for alarm. It is important, therefore, to know the true reasons why young men emigrate and to see whether there is anything that can be done to maintain the rate at which they do at a reasonable level. Unfortunately far too little is known about the factors, economic and social, behind such decisions and there is a good case for a much more scientific inquiry, among those emigrating and those returning, in order to obtain a picture of the complex factors involved. The Advisory Council sought evidence from the universities, the Board of Trade, the professional institutions and the immigration authorities in Canada and the United States, but it must be extremely difficult to nail down the real causes of emigration of some of our best men, or indeed to know whether some of those who go are not already unhappy or unsettled in this country.

The present situation arises out of the great shortage of scientific and engineering manpower on both sides of the Atlantic. If the American need were to fall below our own, their powers of attraction would not be so great. The most obvious attraction is the high standard of living supposedly enjoyed in the United States. A young scientist or engineer with an English Honours Degree can start at an income of about £1,800 a year in the United States, whereas in this country he is lucky if he gets £700 or £800. Any comparison of cost of living is difficult, particularly in the field of those durable consumer goods which play such a big part in American living standards; but, in their enjoyment, the young man in the United States will find himself wealthy, whereas in this country the incidence of Purchase Tax puts them out of his reach in his early years.

America and its way of life are well known through American films, books and so forth, and many young men may feel a desire to sample this exciting world. It is believed that the opportunities for responsible work are greater in American companies and that there is more receptivity in them for original ideas. This view may well be exaggerated, especially in large organisations, but it is an undoubted fact that there is a great deal more money for research in all fields of both the natural and social sciences, for the United States is a large and wealthy country not faced with the balance of payments difficulties which restrict activity in many other countries.

The new Welfare State graduate may also appreciate the less-marked class distinctions which are still a handicap in British society; particularly the absence of that social advantage attached to a private education which compels large numbers of the middle class in this country to stint themselves to send their children to public schools. On the other side, and apart from ties of loyalty, affection and social preference, it is probable that the emigrants, after some time abroad, are not aware of the rapidly growing opportunities in this country and of the increasing salaries being paid for high level work. It would be helpful if they could see every week the pages of appointments advertisements, significantly no longer mainly for defence jobs but in a great variety of fields in industry and the public service. There are many worth-while opportunities to-day.

One difficulty in getting the emigrant back which the Advisory Council points out is that no arrangements are made by universities and firms to interview young scientists and engineers who have completed their fellowships and who would like to return to this country. At the present time many of them take jobs in America because they cannot afford to take the risk of returning for an interview. Here is something which could easily be dealt with, perhaps with the help of our Scientific Attaché in Washington. A healthy exchange of men and women educated and trained under different conditions is undoubtedly an advantage to all of us, but a one-way traffic could become a permanent barrier to the scientific change and advance which are imperative for British industry. It is a form of capital export we cannot afford.

Cover Picture. *Few components are subject to such harsh operating conditions as bearings, and few are required to satisfy such high standards of accuracy. Quality control is therefore a major factor in bearing production. The operator is shown grading ball races for bearing assemblies.*

* * *

Plain Words

On November 3, the gale which blew across England took the roofs off a row of houses in Hertfordshire. Only two days before in ENGINEERING we had published an article on "Wind Loading on Roofs."

Here was an extraordinary example of unpremeditated timing. A specialised, technical article, typical of many we have published in the past, appears in our issue of November 1. In the ordinary way the author could expect some correspondence from other workers in the same field, and from time to time in the future the article would be turned up by someone who found a reference to it in an index or in another article. "Wind Loading on Roofs" was destined to play a more dramatic part. Within 48 hours it was unexpectedly topical; the daily newspapers published photographs of the damaged houses and reports of the afflicted families.

We would like to be able to guarantee similar timeliness to every author. Some articles are, of course, deliberately topical, but only in a general way can it be true of those articles which report advances in some specialised field. These articles are very contrary things to handle and publish. It is impossible to tell exactly what value they will have when they appear in print. Yet it is broadly true to say that if one man is carrying out research and development on reasonably promising lines, there will be others at about the same time who will be doing the same, even if it is for different purposes. The explanation is, of course, that the same set of conditions which lead one man to embark on a new line of inquiry is likely to apply to others who have had somewhat similar backgrounds. All of them are building on the findings of the previous generation; all of them have had rather similar educations, so far as content goes; all of them now work in rather similar environments—the same desire to get the edge on competitors, the same limitations in men, materials and plant. There are many instances in engineering history of more or less simultaneous invention.

After the experience of the wind-loading article it did occur to us to have our own private fire-raisers, roof-raisers and the like, who could go round the country quietly arranging for things to happen in accordance with our editorial programme. We felt that we should be doing a sort of public service, like Robin Hood or the Saint. If brittle fracture, or corrosion, or some other phenomenon is really a menace to civilisation, ought we not to plan something big in the way of calamities and come out with a practical article the same week? We remain open to suggestions.

FLYING TO THE

PROBLEMS IN THE DYNAMICS OF LUNAR FLIGHT

By V. A. Yegorov

Soviet scientists have announced that their next extra-terrestrial objective is the moon. At the recent International Astronautical Congress in Barcelona, V. A. Yegorov revealed some aspects of current Soviet thinking on the subject. He is a member of the Interdepartmental Commission on Interplanetary Communication of the Astronomical Council, Academy of Sciences, U.S.S.R. This article is the author's own summary of his paper, "Some Problems in the Dynamics of Flight to the Moon."

THE problems of lunar flight have been discussed by several authors in recent years, notably by Thürling, Lawden and Buchheim. Up to the present the passive part of the trajectory has not been explained in principle, nor has the effect of scatter in the initial data. This can be explained by the fact that even in the simplest case the problem boils down to the limited-orbit, three-body problem in mechanics, comprising earth, moon and rocket. In this article, which is the report of a study made by the author and his colleagues, an attempt is made to solve the problem in such a way that for the given lunar target the trajectory can be selected which is most suitable in shape and in the effect of scatter in the initial data.

General Study of a Lunar Trajectory.—In the first part of the study a general investigation of a lunar trajectory was made. By using a co-ordinate system rotating with a straight line between the earth and moon and using Jacobi's integral, the minimum initial velocities were determined for a lunar flight. Over the first part of the passive section 200 km. from the surface of the earth, these velocities are equal to 10,849 metres per second independent of the direction of launching. Numerical integration using a computer shows that if such trajectories reach the moon it is only after a sufficient number of rotations about the earth, of the order of 100 or more; and it is possible to estimate the minimum velocity required to reach the moon on the first rotation in a non-rotating system of geocentric co-ordinates in which the effect of the moon is neglected. With vertical firing it is 10,905 metres per second, whilst with inclined firing this is slightly less. By using a method similar to that used by V. G. Fesenkov it was shown that a vehicle could not be captured by the moon within its radius of influence for approaching trajectories (that is for trajectories beginning at the earth and landing within the region of influence of the moon within one revolution).

In working out approach trajectories the numerical integration demonstrated that the effect of the influence of the moon can be neglected outside its sphere of action, and that of the earth within the sphere, and it can be assumed that the corresponding geocentric and selenocentric portions of the trajectory are conic sections. This gives us a simple or close enough approximate method of investigation and allows us to arrive at the basic laws and characteristics of motion.

It appeared that the selenocentric part of the approach trajectory is always hyperbolic; and with initial velocities only exceeding parabolic velocities by 0·5 km. per second, the law approaches an asymptotic one, which corresponds with infinitely high initial velocities.

For motion in the lunar orbital plane it was possible to make an approximate estimate of rocket velocities from the sphere of influence and to analyse the evolution of many approach trajectories for variations in the initial velocity vector. This has allowed us, in the second part of this work, to deal with a series of concrete problems on lunar flight within the orbital plane.

Reaching and Encircling the Moon.—In the problem of reaching the moon, it was found by approximate methods that the deviation of the trajectory from the moon's centre is a quadratic and not a linear function of small errors in the initial data. The maximum allowable errors for each of the initial variables were determined or evaluated. It appears that with errors in initial speed of the order of 50 metres per second and in direction of the order of 0·3 deg., for initial velocities close to parabolic, the trajectory still goes through the moon. The effect of errors in the initial position was not very great.

The problem of encircling the moon and returning to earth was found to have two kinds of solutions. Two kinds of earth return trajectories were also found, but not involving encirclement —the so-called "reaching" (*doletnikh*) trajectories. Deviation in trajectories from the centre of the earth on the return journey was also found to be a quadratic function of error in the initial data. Thus the effect of scatter in the initial data decreases with increase in the distance of the approach trajectory from the moon. For distances of the order of the radius of influence (66,000 km.) accuracies required for returning to earth after encirclement are no higher than those required for landing on the moon for the same initial velocity.

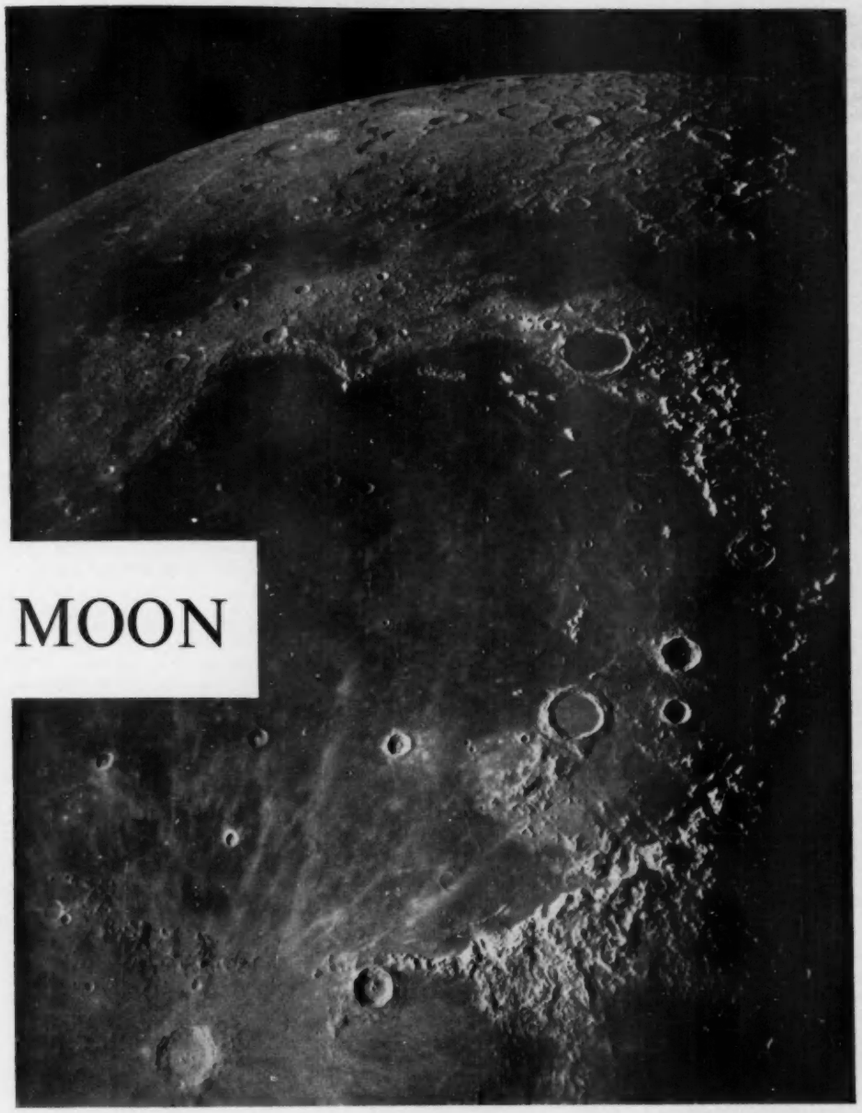
The more interesting problem of encircling the moon with inclined entry to the earth atmosphere comes under the same heading. Owing to the relative thinness of the atmospheric layer, the required accuracy in initial data is ten or more times than in the foregoing problem.

Periodic approach trajectories in the lunar orbital plane have one family of solutions for encirclement and two sequences of reaching (*doletnikh*) trajectory families. Encirclement solutions correspond with hyperbolic initial velocities at about 100,000 km. from the earth and they are unstable.

The problem of maximum rocket acceleration under the influence of the moon has two classes of solutions which go round the moon on opposite sides close to its surface. The trajectory of mirror-image acceleration corresponds to the maximum deceleration of the rocket as it returns from the interplanetary flight. Owing to the small distance of the trajectory from the moon, for acceleration to take place that is sufficiently close to the maximum, it is necessary to have very much higher accuracy in initial data than for a simple case of one-way flight.

In addition to those already discussed, there are also approach trajectories which involve greater or less rocket deceleration with respect to the earth; there are no other trajectories. Thus the classification of plane approach trajectories is complete.

In all these problems the solutions of various classes for various magnitudes and directions of initial velocity have been obtained by using



approximate methods. Iterative methods were evolved for establishing a trajectory of a given kind by integrating the equation of motion to the three-body problem on an electronic computer. Owing to this consideration, nearly all the results obtained by the approximate method were confirmed by the more accurate method. The machine also enabled the necessary accuracy of initial data to be evaluated. More than 1,000 trajectories were estimated.

In conclusion, the following deductions can be made. Owing to the high demands for accuracy in initial data to obtain a close flight round the moon and especially one with inclined re-entry into the earth's atmosphere, correction of the passive part of the trajectories by incorporating an auxiliary power unit is involved. For single-flight lunar trajectories and long-range encirclement trajectories the demands for accuracy are fairly reasonable, so that flight along these trajectories could be achieved without corrections over the passive portion, since rockets will be able to attain the velocities of the order of parabolic velocities.

It should be noted that despite the necessity for correction in obtaining these solutions they are still of practical value because they require less correction than other solutions.

It should be remarked also that these results can be used as a first approximation for an accurate trajectory search for given conditions, taking into account disturbances from the sun and other secondary factors. In this case the method of determining the trajectory would be retained. In addition to the above, the methods and results of this work could be generalised for the case of flight from the earth to the outer planets of the solar system.

The illustration on this page shows the north-east quadrant of the moon in its last quarter. The photograph (Pal. 257), which is reproduced by courtesy of the Mount Wilson and Palomar Observatories, was taken with the 100 in. Hooker telescope.

Another paper presented at the Barcelona congress was concerned with a similar problem of navigation, the solution of which may be regarded as preceding the calculations discussed above. Some comments from the paper, " On Placing a Satellite in Orbit," by D. E. Okhotsimsky and T. M. Eneev, are given below.

The paper considers the problem of placing an earth satellite in orbit. It is assumed that this is carried out with the help of booster rockets consisting of one or several stages. The law of change in thrust with respect to time is investigated, with the object of delivering the satellite into its orbit with the minimum consumption of fuel. In the first part the authors discuss the problem of choosing the thrust-control programme and simultaneously the fuel-consumption regime. In the second part they deal with the question of choosing an optimum programme for a multi-stage booster with a variable number of stages assuming that the fuel-consumption regime is given. In the third part the whole question is generalised, that is, the question of placing a satellite in orbit in a variable central gravitational field, making allowance for the earth's rotation. Reference will be made here only to the first section.

Over the delivery path it is necessary to solve the problems of rising to a given height and imparting a given velocity in a horizontal direction. The results obtained show that in the most favourable case when the delivery time is also chosen as optimum, the increase in velocity and height should be carried out by applying sudden impulses right at the beginning of motion. Delivery into horizontal direction of motion must be effected by gravitation. If the given time of delivery is different from the optimum, it is necessary to employ an impulse imparted at the end of the path in order to turn the satellite into a horizontal direction. If this given excess time is too great the deviation in velocity vector due to gravity is more than necessary and the vertical component of a second impulse should be fired upwards. If the given time is small, gravity will not have time to influence the velocity vector and a partial turn should be imparted, again by a second impulse having a vertical component directed downwards.

In obtaining solutions, the authors departed from the assumption that it is possible to apply an impulse instantaneously and to burn the entire fuel or part of it instantaneously. As this is actually impossible, the best solution of the problem is obtained by replacing instantaneous burning by burning the fuel at the maximum specific rate, and the interval between the applied impulsive movements by periods of minimum specific fuel consumption or, even better, by motion with the power disconnected.

It was deduced that in motion in a plane-parallel gravitational field the best path is obtained by applying one impulse at the beginning of motion. This solution, however, is inapplicable for placing a satellite into an orbit with a central or radial field of force, because it is impossible to obtain, for instance, a circular orbit or an orbit which does not intersect or is not tangent to the surface of the earth. Therefore, in applying the solution of the problem in a central force field, the most important factor is the problem of delivering the satellite into orbit in a given time. If the given time is not too great the dimensions of the delivery trajectory will not be great with respect to the radius of the earth, and the hypothesis on which the study was based will not be significantly invalidated.

It can be shown that in accordance with a reduction in the delivery time, the cumulative effective velocity increases, the magnitude of the initial impulse drops, and that of the final impulse increases. The magnitude of the initial angle increases with decrease in time of delivery, the trajectories become steeper and the horizontal range decreases. It is also apparent that these values of horizontal range are very much less than the radius of the earth. In an example it is estimated that to deliver a given satellite to a height of 300 km. with a horizontal velocity of 7,900 metres per second the optimum delivery time in a plane-parallel force field is 248 seconds. (The orbit of the first Soviet satellite has ranged in height from 200 to 800 km. with an average speed of 8,000 metres per sec.)

POSSIBLE FUELS FOR SPUTNIK II

High-Energy Propellants?

By a Fellow of the British Interplanetary Society

The following note, prepared for us by a Fellow of the British Interplanetary Society, suggests that hydrazine or pentaborane, with liquid oxygen, may have been used to launch Sputnik II.

The launching rocket used to put Sputnik II into its orbit is believed to have been operated on a propellant combination with a higher performance than is available with the commonly-used liquid oxygen and kerosine or gasoline. Restricting our inquiry to available chemical propellants, rather than nuclear power plants or the use of free radicles or atomic hydrogen, we may see what can be obtained by changing either fuel or oxidant; and what difficulties are associated with the use of the more unusual materials.

The overall performance of a propellant combination in a particular design of vehicle depends on a number of factors, including density and heat transfer effectiveness, but the most important criterion is the velocity which is achieved, relative to the rocket, by the exhaust products, since it is upon this that the required mass of propellants depends, for a particular vehicle and payload. Making assumptions of constancy of specific heats and molecular weight of the products, and of one-dimensional adiabatic isentropic flow, we have the well-known relation for the exhaust velocity:—

$$v = \left[\frac{2g\gamma}{\gamma - 1}\,\frac{R\,T_1}{M}\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\right\}\right]^{\frac{1}{2}}$$

where v is the exhaust velocity, γ the ratio of specific heats, $\frac{c_p}{c_v}$, R is the universal gas constant, M the mean molecular weight of the products, T_1 the combustion temperature, and p_1, p_2 the static pressures at the inlet and outlet of the nozzle.

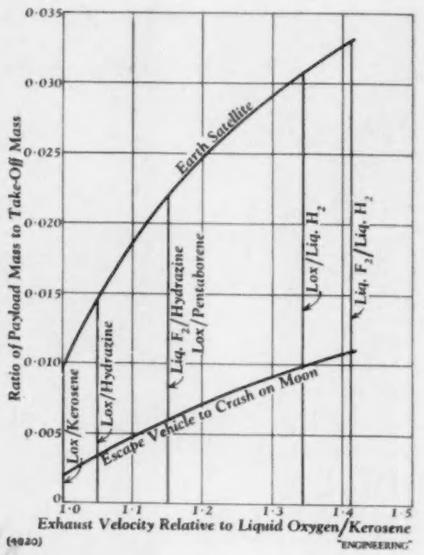
In any real rocket engine this relation will not be followed exactly, due to non-ideal processes (friction and heat losses) and to deviation of the gas from its ideal state; dissociation takes place, the specific heats varying with temperature, and there are effects due to relaxation processes. Nevertheless, the main conclusions demonstrated by the relation do not suffer any great change, and we find that, for a high exhaust velocity, it is necessary to choose a propellant combination which gives a high content of chemical energy per unit mass (and hence a high combustion temperature) and also a low value of the mean molecular weight of the exhaust products. While a low value of γ increases the velocity, the effect is not very marked, and in any case it is not possible to choose from a wide range of values of γ with existing propellants. The table shows some data on the theoretical performance of some propellant combinations. In every case, expansion to one atmosphere (14·7 lb. per sq. in.) is assumed, and in most cases it has been taken that the exhaust gases, once they have passed the nozzle throat, retain constant composition, rather than assuming that dissociated molecules recombine in the divergent part of the nozzle. If the flow were such that equilibrium was maintained throughout expansion, an increase in exhaust velocity of up to about 5 per cent. might be achieved in comparison with the constant-composition case, but it is not at present possible to influence the flow in this way at all, and most engines are found to operate between the two extremes.

The values of exhaust velocity shown in the table will be increased somewhat (by say 5 per cent.) if the gases are allowed to expand in the nozzle to a lower pressure such as would be encountered in the high atmosphere or beyond.

Following the analysis of Dr. L. R. Shepherd of the British Interplanetary Society, to which reference was made in the October 18 issue of ENGINEERING (page 485), we may assess the changes in payload ratio (mass of payload/total mass at take-off) which would be caused by a change in exhaust velocity, assuming the vehicle structure weight factor to remain unaltered at 0·10. The accompanying graph shows the results for two cases: a satellite vehicle, and an escape vehicle intended to crash on the moon. The improvements in payload ratio corresponding to even small changes in exhaust velocity are obvious. For the satellite, substituting hydrazine for kerosine with liquid oxygen increases the payload ratio from 0·0096 (say 1/100) to 0·0145 (1/70), while liquid oxygen/pentaborane gives us 0·022 (1/45), a reduction of a half in the launching weight compared with liquid oxygen/kerosine.

Fluorine gives an even greater reduction in take-off weight: for the vehicle crashing on the moon, liquid fluorine/liquid hydrogen allows the use of a payload of the same size as Sputnik II (one ton) with take-off weight of under 100 tons in the circumstances assumed.

It must be noted, however, that such increases in performance do not come easily: such materials as fluorine and hydrazine are extremely toxic, and the efflux from a fluorine-burning rocket may be lethal. The high combustion temperature associated with fluorine, and the absence of any suitable heat-transfer medium when both propellants are liquefied gases, make the design of a reliable combustion system extremely difficult. The low specific gravity of liquid hydrogen (about 0·07) means that large tanks are needed, thus increasing the structure weight. These difficulties would indicate that Sputnik II is likely to have been propelled by rocket engines using liquid oxygen and hydrazine or pentaborane, since these combinations give a worthwhile reduction in take-off mass without undue complication in the design of the engines. The "exotic" propellants are very expensive, but the saving in vehicle take-off mass, at a price of say £10,000 per ton, soon allows the propellant cost to be written off.



Effect of exhaust velocity on payload ratio.

References

[1] *Rocket Propulsion Elements*, by G. P. Sutton. 2nd edition, Chapman & Hall (1956).

[2] L. R. Shepherd, Proceedings of the College of Aeronautics/British Interplanetary Society/Royal Aeronautical Society High Altitude and Satellite Rocket Symposium, College of Aeronautics, Cranfield, July 18 to 20 (1957). (To be published.)

TABLE.—*Data on Theoretical Performance of some Propellant Combinations*[1,2].

Propellant Combination, oxidant/fuel	Combustion pressure, lb./sq. in., abs.	Mixture ratio, oxidant/fuel	Combustion temp., deg. K.	Mean molecular weight	Ratio of specific heats	Exhaust velocity, ft. per sec.
Liquid oxygen/kerosine	300	2·2	3,400	21·6	1·26	7,970
Liquid oxygen/ethyl alcohol ..	300	1·5	3,180	22·9	1·22	7,810
Liquid oxygen/ammonia ..	300	1·4	3,000	19·7	1·23	8,220
	500	1·3	3,000	19·0	1·23	8,550
Liquid oxygen/hydrazine.. ..	300	0·5	2,750	15·9	1·23	8,350
Liquid oxygen/liquid hydrogen ..	340	5·33	3,270	11·7	1·25	10,800
	500	3·5	2,750	9·0	1·26	11,700
Liquid fluorine/hydrazine ..	300	1·9	4,100	18·0	1·33	9,610
Liquid fluorine/liquid hydrogen ..	300	?	4,200	?	?	11,750
Liquid oxygen/pentaborane ..	?	?	?	?	?	9,600

Letters to the Editor

MORE STEEL OR BETTER CONCRETE

SIR, I was surprised to discover that the article on page 564 of your issue of November 1," More Steel or Better Concrete for Cheaper Designs : an Economic Approach to Reinforced Concrete," contained the assumption of elastic behaviour of both concrete and steel as the basis of an analysis of the economics of beam sections.

C. S. Whitney, in " The Ultimate Strength of Concrete Beams," *Trans. A.S.C.E.*, vol. 107 (1942), and others have produced much experimental evidence that reinforced-concrete beams do not behave in accordance with such a theory. Sections designed by elastic theory are often uneconomic and alternative ultimate load methods have been introduced into recent codes of practice, including the British Standard Code of Practice, C.P. 114 (1957).

The new methods, based on experimentally verified theories of plasticity, permit the economic use of high-strength steel with normal-strength concrete. However, one of the conclusions given in your article reads as follows: " Under no circumstances can the use of a more expensive steel, albeit with a higher maximum permissible stress, give any advantage in the total cost over the use of mild-steel reinforcement with a maximum permissible stress of 18,000 lb. per sq. in." This statement is a direct consequence of the fallacy of the elastic theory. Experiments indicate that by doubling the yield strength of the steel one can double the moment of resistance of rectangular beams having about 1 per cent. reinforcement. Although not permitted in elastic theory designs, the same result could be achieved by using twice the amount of normal steel with more expense and greater congestion of reinforcement. Contrariwise, the conclusion that it is an advantage to use high-strength concrete with normal-strength steel is incorrect, except when shear forces govern the design.

To conclude, we cannot expect to obtain economic designs unless we pay some attention to ultimate load capacity. By adopting " work-

ing stress" criteria we may be obtaining "economies" through variations in the factor of safety against ultimate failure.

Yours faithfully,

GEOFFREY BROCK.

11 Catholic-lane,
Dudley, Worcestershire.
November 12, 1957.

SIR, On page 564 of your issue of November 1, Dr. J. R. Lawrence in his article entitled "More Steel or Better Concrete for Cheaper Designs" uses a range of values for r between 10 and 30, whereas our information produces values of about 100. Further, by substituting $r = 100$ into equation (9) of that article, we find that the cost reduces as the steel stress rises, which agrees with our experience in practice, but which is quite the opposite to the conclusion drawn in the article. Because the validity of the conclusions depends on the values of r we would very much like to know how the value of 30 was arrived at.

We give below our calculation for r.

Yours faithfully,

D. N. MITCHELL, M.I.C.E., M.I.Struct.E.
C. W. A. REAY, B.Sc. (Eng.), A.M.I.C.E.

33 Bunns-lane,
Mill Hill,
London, N.W.7.
November 13, 1957.

Calculations for $r = \frac{\text{cost of unit volume of steel}}{\text{cost of unit volume of concrete}}$

Prices from the November 1 issue of *The Builder*:

Cement £5 12*s.* 0*d.* per ton.
Washed sand £1 7*s.* 8*d.* per cub. yard.
¾ Shingle £1 4*s.* 0*d.* per cub. yard.

4 cub. ft. shingle yields	2·14 cub. ft.	Costs	3·56*s.*
2 cub. ft. sand yields	1·01 cub. ft.	,,	2·05*s.*
1 cub. ft. cement (90 lb.) yields	0·46 cub. ft.	,,	4·50*s.*
50 lb. water yields	0·80 cub. ft.	,,	—
Total quantity	4·41 cub. ft.	Total cost	10·11*s.*

Allowing 2 per cent. void, say 4·5 cub. ft.

Accordingly, the cost of the concrete is:

$$\frac{10{\cdot}11 \times 12}{4{\cdot}5} \text{ or } 27d. \text{ per cub. ft.}$$

Steel, weighing 490 lb. per cub. ft. and costing £50 per ton =

$$\frac{50 \times 240 \times 490}{2240} = 2{,}620d. \text{ per cub. ft.}$$

Therefore, excluding labour and shuttering, $r = \frac{2620}{27} = 97.$

Including labour, but excluding shuttering:

Typical concrete costs 40*d.* per cub. ft.
Typical mild steel reinforcement costs 7·5*d.* per lb., or 3,680*d.* per cub. ft.

$$r = \frac{3680}{40} = 92.$$

N.B.—The ratio by weight is $\frac{92}{3{\cdot}26} = 28{\cdot}2.$

AMERICAN WOMEN

SIR, As a woman chemist, I found the leading article "Men Only?" on page 129 of your issue for August 2 very interesting. I especially agree with your statement ". . . don't try to compete with men, not because you might embarrass them if you beat them at their game, but because there are various kinds of work available which will appeal to feminine natures. . . ." From my own varied experience, I would like to recommend those of technical editor and literature scientist to my feminine colleages.

Although there is some prejudice against women scientists and engineers in the United States, I am happy to state that it is less than the classified advertisements in *Nature* seem to indicate is the situation in England. At least, such advertisements in the United States do not baldly state a male and a female salary scale; we do have such a double standard in actual practice in most organisations except the Government. During a speaking tour recently, I had the opportunity to discuss such matters with Canadian women scientists and was happy to find that there is less prejudice against women in Canada.

I was also interested in the article "Management is Hampered by Bad Technical Writing" because I had assumed that your English school system would turn out graduates at least reasonably competent in their mother tongue. (See ENGINEERING, August 2, page 137.) After all, technical writing is only expository writing characterised by the reporting of technical data. The problem of poor technical writing is quite serious here in the United States and, I was quite surprised to learn, in Canada, too. In the United States, many organisations are trying to solve the problem by on-the-job training courses. I teach such classes of Foundation personnel every year, although all our scientists and engineers have at least baccalaureate degrees and some even have doctorate degrees.

Sincerely yours,

ETHALINE CORTELYOU (MRS.),
Literary Analyst.
Armour Research Foundation of Illinois
Institute of Technology,
Chicago 16.
October 29, 1957.

"THE FULL PLASTIC MOMENT"

SIR, The ultimate strength in bending of engineering materials is of interest to mechanical engineers to the same extent that it is to civil and structural engineers, so that the letter on "The Full Plastic Moment" reproduced in your correspondence columns of October 18 (page 487) has attracted my attention.*

It appears that the plastic theory of structural design has been based mainly on the mechanical properties of mild steel, which is the lowest grade of steel available. The better grades of steel and of alloy steels, particularly when they have been hardened by heat treatment or other means, do not show the pronounced break in the stress-strain curves so evident at the yield point of mild steel, and all grades of cast iron have no proper yield point. The suggestion that hard materials of this kind become plastic, when the calculated modulus of rupture has reached a value of about 50 per cent. in excess of the ultimate axial strength, is not acceptable; especially is this so in the case of cast iron, where the calculated modulus of rupture of square or rectangular section bars may reach a value of about 70 per cent. in excess of the tensile strength and of solid round-section bars about 100 per cent., depending on the size of cross-section and also on the spans across which they are tested. The excessive ductility of mild steel appears, therefore, to reduce the modulus of rupture rather than to increase it.

It is more than 100 years since mild steel was first manufactured by British initiative and at that time contributed to the lead established by British engineers in many fields of engineering. Since that time there has been very little improvement in the quality of commercial mild steel, so that the introduction of better materials may be the means of regaining our lead, rather than the adoption of doubtful methods of calculation.

Yours faithfully,

J. R. HOWGEGO.

Golf Links-road,
Ferndown, Dorset.
November 5, 1957.

SIR, The objections raised against the theoretical nature of the conception of the full plastic moment in the letter of Mr. Proctor should not be reason why the plastic method of designing structures may not be considered to be an acceptable method of structural design. After more than 40 years of research on the Continent, where the idea of plastic bending originated, the subject is now to be introduced into technical education in this country.

All that appears to be required would be a systematic investigation into the internal stress distributions in beams of several kinds of materials when loaded to their maximum capacities, using the modern methods of research that are now available. Transparent materials having stress/strain characteristics similar to mild steel, etc., could be tested by photo-elastic methods and some information about the internal condition in opaque brittle materials might be deduced from ultrasonic tests and other modern methods of testing.

Although it is true that Barlow's ideas were largely responsible for the introduction into this country of the Navierian theory of bending, the tests he made were mainly on cast-iron beams about 6 ft. long; his theory of the resistance of flexure, taking into account the effect of the transverse strains, was not seriously considered (ref. *Phil. Trans. Roy. Soc.*, vol. 145 page 225 [1855] and vol. 147 page 473 [1857]) although it gave more accurate results than the elastic theory. The equipment available in Barlow's time was not comparable with that available to-day, so that there is little cause for surprise that he described the difference between the actual and the theoretical as a paradox.

Yours faithfully,

DAVID IAN BRINDLE.

142 Brighton-road,
Alvaston, Derby.
November 15, 1957.

* *Editor's Note.*—Other letters on this subject appeared on November 15, page 615.

FRICTION UNDER CONTROL

SIR, The article "Friction Under Control" (ENGINEERING, November 8, page 597) describes a process, the effects of which are so similar to those created by bonded coatings of molybdenum disulphide that the reader who has used such coatings might be forgiven for assuming that the process was, in fact, a molybdenum disulphide bonded coating.

These coatings have been developed to overcome lubrication difficulties under conditions which are beyond the range of conventional lubricants. They consist usually of a highly refined form of molybdenum disulphide, mostly in micronated or colloidal form, a binder and a diluent. The attached table shows a number of bonded coatings which, under proprietary names, are available to engineers who wish to treat parts themselves. The method of treatment is usually as follows:

1. *Cleaning.*—In the case of bonded coatings to surfaces, the latter must be absolutely clean. Vapour degreasing (such as trichlorethylene, carbon-tetrachloride), followed by wiping with ethyl alcohol and drying, is often necessary. Usually, however, the vapour degreasing alone is sufficient.

2. *Pre-treatment.*—It has been shown that a molybdenum disulphide bonded coating has better wearing and endurance features when applied to a surface which has been pre-treated with a process such as iron manganese phosphate, black oxide, anodising by the chromic-acid process, sulphurising, bright dipping, or liquid hone grit blast. Practical experience suggests that pre-treatments for bonded coatings should be used wherever possible.

3. *Application of Bonded Coating.*—The bonded coating is usually dipped or sprayed on the cleaned and pre-treated surface. Some treatments require the heating of the part to temperatures from between 200 deg. to 500 deg. F. before application. Others can be applied to surfaces at room temperature.

4. *Curing.*—The most effective bonded coatings of molybdenum disulphide are those which are cured (baked) for a period of time. The maximum curing temperature that has been found effective is in the region of 650 deg. F. and the average temperature for the best type of bonded coating does not usually exceed 550 deg. to 600 deg. F. Bonded coatings are available to give effective coatings at lower temperatures, including room temperatures.

5. *After Treatment.*—In a few cases, it is necessary to treat the bonded part by polishing, wire brushing or some similar means, to remove the products of bonding. The thickness of the bonded coating should be in the region of from 0·0002 in. to 0·0005 in.

Practical uses for bonded coatings exist in all

Continuing Letters to the Editor

industries; for instance, the aircraft industry employs them on many parts, such as linkages, valves, keys and couplings. In many cases, standard lubricants are used after the application of the bonded coating, the latter acting as a safety layer to prevent pick-up and scoring during periods of point-to-point contact.

In the United States there are a number of companies selling a treatment service, but in this country engineers prefer to treat materials themselves, particularly as the equipment for treatment is usually already available in engineering works and, in this case, companies have more control from an engineering, cost and knowledge point of view, as well as from a time point of view which, in the case of urgent deliveries, is a very important factor.

Pressure Bonds.—Whilst bonded coatings fulfil an important function, they should not be used where molybdenum disulphide concentrates and dispersions will perform an equally satisfactory and economical function. For instance, in many tapping operations, particularly when tapping stainless steel and plastics materials, the application of a small amount of high-concentrate paste to the tap during the operation is as effective as a bonded coating and has been shown to increase the life of taps several thousand per cent.

In the case of an internal-combustion engine, where a bonded coating treatment would usually cause great inconvenience, the application of molybdenum disulphide in dispersion form, added to the engine oil, has been found to give enormous wear reductions. Added to the engine of an Austin A.50 Countryman motor van which was run with molybdenum disulphide dispersion in the oil for several hundred miles, it was possible to drain the oil and drive the van, without any oil whatsoever, from Crediton in Devon to London, then to Brighton and back again to London—a distance of 300 miles. The wear in the cylinders was between 0·0005 in. and 0·0001 in. This wear included the running-in wear. The addition of a molybdenum disulphide dispersion to cutting oils has greatly increased the life of hobs and broaches. In some cases, a bonded coating, while not as efficient from a mechanical point of view, may be more desirable on economic grounds.

In the case of plain bearings, whether from a running-in point of view or as a first-aid material, the use of molybdenum disulphide in paste or liquid dispersion form is preferable to the application of a bonded coating, particularly because, as a paste, it can be applied with the machinery running or, if not running, not disassembled, an important factor in plant engineering.

Mr. A. Milne (*Wear*, October, 1957) has shown that the maximum distance obtainable with his best bonded coating was 50 km., whereas the effect of using a high concentrate paste of molybdenum disulphide, such as pressure bonding, lasted throughout the 1,000 km. of the test. In both cases, the molybdenum disulphide was applied to pre-treated surfaces, but similar results occurred when MoS_2 was applied to non-treated surfaces. The interesting result was that a pressure-bonded surface on an otherwise untreated surface was still better than a molybdenum disulphide bonded coating on a treated surface.

Summing up, therefore, it can be said:

1. The use of molybdenum disulphide, whether in the form of concentrates or dispersions (usually pressure bonded), or in the form of bonded coatings, can overcome, in many cases, operating conditions which are beyond the range of conventional lubricants.

2. In selecting the method of application of the material, the engineer can choose between molybdenum disulphide concentrates or dispersions on the one hand, and bonded coatings on the other. The former are more simple to apply, the molybdenum disulphide being pressure bonded into the material by the action of the operation.

3. If bonded coatings are to be used, the correct type and method of application should be considered, such as whether the bonded coating is to serve as a dry lubricant or as a base only for a conventional lubricant.

A great deal of experience has been gathered and suppliers of molybdenum disulphide compound, dispersion or bonded coating, would usually readily advise engineers as to the method and material which are technically best and most economical. Although the writer cannot subscribe to the material being "revolutionary," he does feel that the technical and commercial scope of the application of molybdenum disulphide in industry are very great indeed.

Yours faithfully,

H. PETER JOST, M.I.Mech.E.,
Managing Director.

K. S. Paul (Molybdenum Disulphide) Limited,
Park Royal-road, London, N.W.10.
November 12, 1957.

TABLE.—*List of Selected Bonded Coatings of MoS_2.*

Composition base	Baking temperature, deg. F.	Baking time, hours	Operating range, deg. F.
Dextrose base ..	550 to 600	1	−100 to +800
Nitrocellulose-	475	1	−100 to +800
Xylole	400	2	
Epoxy resin base ..	400	½	−100 to +750
	300	1	
Vinyl butyral resin ..	None	Min. 24	−100 to +750
Or on			
Metallic materials	250	½ hour	—
Thermo-setting materials ..	200	½ hour	—
Fabrics, rubber and thermo-plastic materials	160	1 hour	—

REVOLUTION ON THE LANDING STRIP?

SIR, I have been very interested to read the article on "Revolution on the Landing Strip?" which appeared on page 478 of your issue of October 11.

It was gratifying to note that ENGINEERING has taken notice of the Jet Operations Requirements Panel. The status of their report is still that of a report to the Air Navigation Commission and, as such, has not yet received the formal endorsement of the International Civil Aviation Organization.

Yours very truly,

A. FERRIER,
Assistant Secretary General,
Air Navigation.

International Civil Aviation Organization,
International Aviation Building,
Montreal,
Canada.
October 24, 1957.

ACCEPTANCE TESTS

SIR, You were kind enough on page 521 of the issue of ENGINEERING for October 25 to announce the publication of British Standard 2885: "Code for Acceptance Tests for Steam-Generating Units." As you so rightly made clear, the new Code superseded the one published in 1927 by the Heat Engines Trials Committee of the Institution of Civil Engineers and still regarded as an effective source of knowledge on this subject.

In one respect, however, your note unfortunately gave a wrong impression, by suggesting that there could be some connection between a code of testing for boilers and reports of "explosions and other such calamities." The fact is, of course, that the Code does not deal in any way, even indirectly, with safety or constructional features, but solely with testing procedure for performance of boilers.

Yours faithfully,

G. WESTON,
Technical Director.

British Standards Institution,
2 Park-street,
London, W.1.
November 15, 1957.

Companies in the News

Hawker Siddeley Group

Over the past two years the Hawker Siddeley Group have made strenuous efforts to diversify their activities outside engineering and now other activities account for 70 per cent. of their interests as against 15 per cent. when the programme began. The expansion, especially the acquisition of the Brush Group and the Dominion Steel and Coal Company of Canada, in which they hold a 76 per cent. interest, has helped to swell turnover to an estimated £260 million this year. Assets of £214 million are now employed in the company, of which rather more than half are in Canada and it cannot be long before additional and more permanent finance must be sought, especially as further expansion appears to be under consideration.

While aviation accounts now only for 30 per cent. of their activities, there is no intention of allowing this side to melt away completely. The order book for the Hunter and Javelin is reputed to be full for some years ahead and the Arrow, a new high speed interceptor developed by the Canadian company, is attracting interest. At the same time the group have offered to develop at their own expense (a figure of £20 million has been mentioned) a jet airliner for B.E.A. provided a definite order is received. Hawkers have no doubt made this stipulation since their last private venture, the P1121, has not as yet been taken up by the Government and is to be shelved. Of the new ventures of the group, perhaps the most interesting is their entry into the nuclear power field in which they have invested £1 million. If the development of this type of power plant for marine work continues to make good progress, they should be well placed to take advantage of the potentialities through their association with John Brown.

The rate of diversification by Hawker Siddeley in the last few years has been very impressive. After its quick expansion there now remains the problem of digesting its various new enterprises. The group is confident that it has sufficient liquid capital resources for the time being to sustain its £260 million a year turnover but it seems likely that it will have to raise capital from outside in the next year or two. It will also be surprising if it does not have a number of management problems to deal with. Diversification brings a wider spread of industrial risks but usually also problems of control.

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Engines

Two announcements last week suggest that in the design and manufacture of Diesel engines Britain is relatively strong in the medium to small, high-speed range. A large order for Perkins L.4 engines has been placed by Gebr. Claas Maschinenfabrik of Harsewinkel-i.-W. in West Germany. That company have decided to standardise on the L.4 for their self-propelled combine harvester, each of which incorporates four engines. To have secured an order of this kind, which is believed to be for more than a thousand engines a year, is a tribute to F. Perkins' ability to compete in the most competitive of world markets.

In the heavy engine range, foreign designers would appear to be making progress at our expense. Last April the Fairfield Shipbuilding and Engineering Company entered into an

Continuing Companies in the News

agreement with Gebr. Stork and Company N.S. of Hengelo in Holland for the manufacture in this country of the Stork single-acting, two-stroke, turbo-charged Diesel engine in a range of horse-powers up to a maximum of 16,000 b.h.p. Now the Swan Hunter group have followed suit; the Stork engines will be built by Wallsend Slipway and Engineering Company and supplied to both Swan Hunter and Barclay, Curle.

Other news in the engine world concerns the amalgamation of two American companies. The Waukesha Motor Company of Waukesha, Wisconsin, have purchased the complete plant and assets of the Climax Engine Manufacturing Company of Clinton, Iowa. This will give Waukesha, who specialise in the production of heavy Diesels, a fuller range of gas engines up to 600 b.h.p. and a very complete coverage of Diesel engines up to 1,200 b.h.p. In the highly competitive market now developing in this field more companies can be expected to be swallowed up in this country even than in the United States.

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T.I.'s New Record

Another record year's earnings was reported by Sir Ivan Stedeford, chairman of Tube Investments Limited, in his annual statement to shareholders. Trading profits are almost exactly £1 million above last year's level, and are based on a wide range of activities. According to the chairman, the group " will shortly be responsible for the production of some 900,000 tons of steel; it has become one of Britain's " big three " in the fabrication of wrought aluminium, and one of the world's largest producers of bicycles and cycle components. Other new manufactures include rolling mills and ancillary machinery, mechanical conveyors, machine tools and spring automatics. " The move towards greater vertical integration is the result of a need which was felt to " safeguard supplies of tube steel." For similar reasons in the aluminium field, an association has been established with Reynolds Metal of America, the second largest producer of primary aluminium in the United States. Since 1948 the net assets of the group have increased by £50 million to about £80 million, more than half of which has been financed out of renewed profits. Employment has risen from 28,000 to 40,000.

Sir Ivan Stedeford discusses in some detail the relative performance of the group's consumer goods (mainly cycles) and capital goods divisions: " fortune smiled " on their 15 companies in the engineering and general divisions. The disappointing results of the cycle division were made all the worse by the extensive re-organisation needed to concentrate all the manufacturing units in a new factory at Handsworth, including the transfer of operating plant and personnel. But it was not a good year for the bicycle industry as a whole, total sales falling by 22 per cent. The fall in demand was confirmed by the results of Raleigh Industries whose trading profits fell by 27 per cent., from £2·38 million in the year ended at July 31, 1956, to £1·89 million this year. In Raleigh's case also, the fall in trade was accentuated by exceptional losses—amounting to £315,000—in disposal of plant, etc., following the re-organisation of the B.S.A. bicycle interests towards the end of their financial year.

Sir Ivan Stedeford re-asserts his belief in a well-knit but diversified group of companies. His main concern is not with the immediate profitability of his group—" we have with the rest of industry the uncertainties which beset our economy "—but with capital investment in the United Kingdom. He considers that the Government have restricted the growth of capital investment, which he calls " a grave step at a time when there is so much leeway to make up." It is his conviction that " ways must be found of according capital investment in industry a high national priority of the kind that was given to housing after the war." Few will dispute it, many will share it.

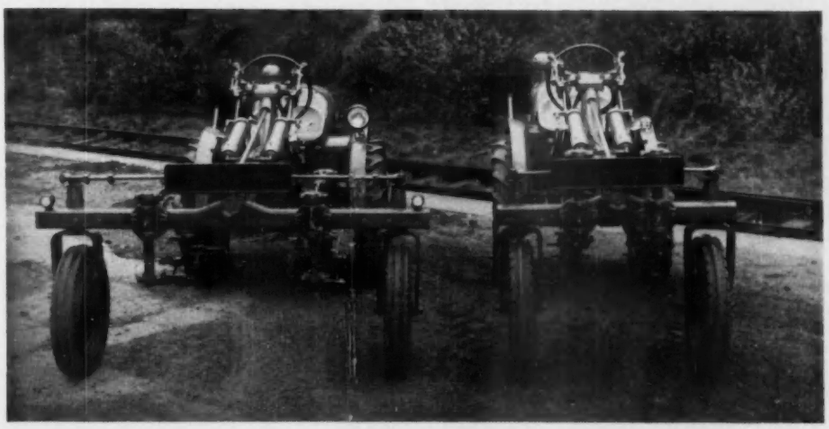
Plant and Equipment

TRACTOR MATCHING EQUIPMENT

Two years ago the firm of Harrison McGregor and Guest Limited, who for 85 years have manufactured Albion agricultural implements, was taken over by the David Brown Group of Companies. Since then, considerable progress has been made in reorganisation at the Leigh (Lancashire) factory, and the first of the new implements resulting are now being placed on the market. It is intended that a complete series shall be made to match with the David Brown tractors, thus creating a wholly British range of agricultural plant. Two of the main features of the new implements are that fabrication has been used in so far as possible in preference to castings, and that fibre glass has been widely employed for covers and similar parts of the machines.

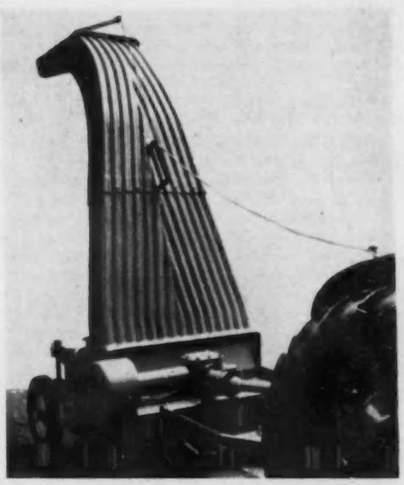
First to come on the market are a cross-ram baler, a forage harvester, a front loader for the 900 type tractor and a rotary tiller. In addition, the present 900 tractor has been modified to have a live PTO, and the 2D tractor has been produced in a narrow variation, particularly for use in vineyards and similar places, having an overall width of only 41 in. As regards the 900 " Livedrive " tractor, the PTO and wheel drive are both controlled by a double-plate clutch. There is a very strong spring incorporated in this which gives what is virtually a stop in between de-clutching the road wheels and de-clutching the PTO. The addition of this clutch has meant a slight increase in length of the tractor, which has been utilised to give extra seating comfort for the driver.

Other changes include a stronger cased-in frame to take the front loader without involving any extra tensions, and the re-positioning of the hydraulic pump behind the rear axle, which



The modified 2D tractor (right) has a minimum width of 41 in. It is designed for use in vineyards.

On the Albion baler (left), the cross ram action enables the driver to keep a watch on operation.



The Hurricane harvester can be used on such tasks as cutting grass to clearing fire lanes in forests. The delivery chute is made of glass fibre.

Continuing Plant and Equipment

gives better accessibility. A traction control unit is fitted and the hydraulic system is equipped with a throttle control allowing the rate of drop of any implement to be selected by the driver.

BALER

The main feature of the new baler, which is driven from the PTO of the tractor, is that the ram travels at right angles to the forward travel of the machine and thus delivers the bale at the side. The advantage of this is that the tractor driver can see not only the pick-up reel but also the other working parts of the machine and even the completed bale as it leaves the chute.

A front-end loader has been designed for the 900 tractor, with a high pivot point and mounted well forward.

The transverse motion also obviates shock to the draw mechanism of the tractor. A single bolt controls the length of the bale and can be adjusted to give sizes between 18 in. and 40 in., according to the crop being harvested. A hand-screw on the side of the machine controls the bale density by contracting or expanding all four sides of the compression chamber simultaneously.

The compression chamber can be raised vertically and held in place by its own links and compression springs, to give a machine of 8 ft. 3 in. overall width when being transported from place to place. When the compression chamber is lowered the width is 11 ft. 6 in. Laminated glass fibre is used for the guards and covers of the working parts for the purpose of giving a smooth line and a non-corrosive surface. The machine is capable of delivering up to six bales a minute, the section being 18 in. by 14 in. The drive to the machine absorbs approximately 7½ h.p.

HURRICANE HARVESTER

The Hurricane harvester also employs fibre glass to a considerable extent, the whole of the lower portion of the delivery chute being a moulding of this material, as well as the guards for the machinery. The horizontal cutter drum, which is driven from the tractor PTO through a step-up gearbox, revolves at approximately 1,200 r.p.m., and creates a sufficient draught to blow the cut material through the delivery chute into a trailer towed behind. To control the direction of delivery, the top section of the chute can be tilted. Adjustment can be made by the tractor driver while the machine is in motion by means of a cord. The drum is 40 in. long and normally has 20 flexible cutting blades. The length of cut can be varied between 2 in. and 8 in. by adjustment of the cutter bar.

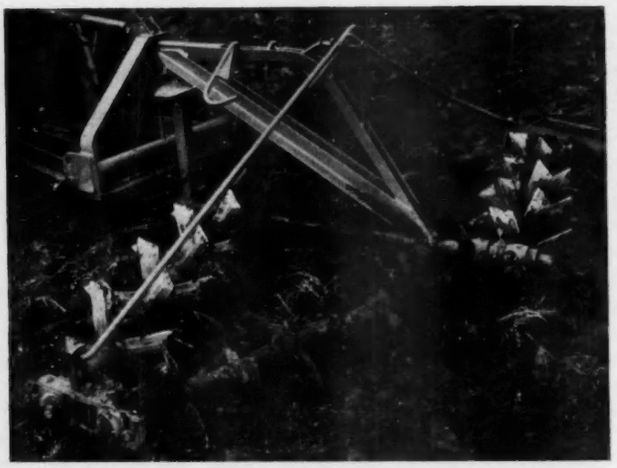
When it is required to use the machine for pulverising, the knives can be replaced by a set of chain links. An over-run pulley is fitted particularly for use with tractors without a live power take-off; this acts as a safeguard against damage to the tractor gearbox, and also prevents the tractor being pushed forward involuntarily by the momentum of the drum. The harvester is for use with tractors of 20 h.p. or over, and it is claimed to be capable of 41 different applications, cutting anything from a grass crop to a fire lane in a forest. It is capable of use in standing crops ranging from 2 in. to 6 ft. in height.

FRONT-END LOADER

The front-end loader is the first to have been designed specifically for use with the 900 tractor. Hydraulically operated, it is capable of lifting over half a ton to a height of 9 ft. It has a very high pivot point to improve the weight transference to the rear wheels as the bucket is loaded and also to provide a longer reach in the raised position. Since the bucket is close to the front wheels, ground level stability and mobility are both improved.

The loader is mounted on a three-point frame, and can be removed from the tractor if required. In this case the hydraulic rams are linked to stowage positions provided on the tractor body. The forward mounting of the frame gives good visibility and enables the load to be discharged 4 ft. in front of the tractor bonnet; a tractor cab can also be fitted if required. Tipping of the loader bucket is effected by a hand lever attached to the cross shaft at the base of the arms. An improved bucket return mechanism and latch has been incorporated.

The bucket can be replaced by a seven-tine fork with a detachable dirt plate or a loader platform, which is a steel framed wooden extension 72 in. long and 29½ in. wide, fitted on the fork tines. Adjustment to the linkage of the loader allows the platform to remain level at all heights. Either a dirt bucket of 9 cub. ft. capacity or a root bucket of 16 tines and 14 cub. ft. capacity can be fitted. There are three positions of attachment for the rams on the lift arms thereby giving three alternative power lifts.



The blade action of the rotary tiller is between that of a disc harrow and a rotary tine cultivator.

ROTARY TILLER

The rotary tiller, which is being made under licence, consists of a series of blades carried on four axles linked in diamond formation, and in action is somewhere between that of a disc harrow and a rotary tine cultivator. It will operate best at fairly high speeds of travel, 7 to 8 miles an hour, and gives a cutting and chopping action to form a fairly coarse tilth. The shafts are carried in dust-sealed ball bearings. It is available in three widths, ranging from 7 ft. 6 in. to 9 ft. 10 in., to suit tractors of varying horse-power.

MACHINE TO MARK CONTAINERS

This machine will impress code markings on the base of containers at a rate of 60 per minute. It is powered from the electric mains.

It is sometimes required that aluminium containers should be coded by having some mark impressed on the base. A machine has been developed for this purpose by Alite Machines Limited, Pixmore-avenue, Letchworth, Hertfordshire. It is fully automatic and shown in the accompanying illustration.

The aluminium containers are fed by hand or, where the unit is part of a conveyor line, automatically, into the magazine. The container then drops on to a locating V-block, a mandrel advances and carries the container across the machine to force the base against the coding type on the anvil. This causes an impression to be made. The mandrel itself is spring loaded to prevent damage to the container.

The mandrel then moves back to its original position and during this movement the container, which is a loose fit, drops a fraction, so that on its return journey the end of the locating V-block catches against the rim. The mandrel continues to move back and the container drops through the output chute either into a hopper or on to a conveyor. The next container now moves into place and the cycle is recommenced.

The speed of this automatic coding machine is 60 articles per minute. Magazines, mandrels, etc., are interchangeable, thus the basic unit with a set of alternative parts can be made to operate on containers of from 1½ in. to 2 in. in diameter and from 1½ in. to 6 in. long. The code type is quickly and easily changed. The unit derives power from the electric mains and can therefore be moved to any convenient position in the factory.

Management

THE MANAGERIAL SIGNIFICANCE OF RESEARCH

By H. J. Novy

The momentous engineering achievements of recent weeks would have made more appropriate "Bournemouth—signpost to better research management" rather than the more workmanlike title "Research—signpost to better management" which the British Institute of Management took for the title of their annual conference. It was held at a time when the whole nation was research-conscious as never before, at any rate aware that the Sputnik and research went together and that to be without Sputniks is not very clever, especially on the part of the Americans who appear always to have everything they want in a bigger size than anyone else. But the 600-odd top managers—the imaginative cream of British industry—assembled for a three-day conference at Bournemouth knew that much more was involved than implied military supremacy. They realised, and many talked about it in hotel lounges and conference room corridors, that it was the commercial future of our country which was at stake and that good management and husbandry was needed in the research field to prevent our being left out on an export limb. A better managed effort rather than a greater one. Some were even heard to say that we had plenty of scientists and engineers if only we made proper use of them.

But nothing so heretical was said in conference. Papers succeeded one another in tidy workmanlike order. Some were good and others not so good, but none had the spark which fires the imagination and tells the listener he is hearing something vital and live. No one rose to the occasion, not even the most likely man to have done so—Viscount Monckton of Brenchley, chairman of the Midland Bank, and one of the most lively and imaginative Ministers of Labour that the country has had since the war. His theme for the opening address was "Who Pays for Research?" He concluded that the qualities which are required in successful research were equally valuable in the art of management—"the open and observant eye; the alert and inquiring mind; the steady perseverance in the pursuit of truth; and the sense of life and work as a great adventure."

DISTURBING THOUGHT

It was left to Dr. Alexander King, formerly of D.S.I.R. and now the deputy director of the European Productivity Agency, to shake up our complacent sleepiness in Bournemouth's gaudy town hall.

He spoke of the Russian satellite which had "shattered our complacent idea of the state of development of that country" and directed attention to the economic aspects of the advance: "... this magnificent achievement is probably most important to this country as an indication of the scientific and industrial capacity possessed by the U.S.S.R., which will increasingly influence our own position with regard to world trade in industrial products. Fear of war may well diminish but industrial competition based on impressive scientific and engineering resources becomes more imminent each day." Most of us felt that this was the vital message which the conference should have discussed, but it came too late on the second day to have much effect on subsequent speakers. Incidentally there appears to be a tendency on the part of speakers to come to deliver their paper and leave at once. They have thus no opportunity to feel the pulse of the conference and its atmosphere, or for discussion with delegates.

Success in the development of a scientific spirit and engineering achievement, said Dr. King, was dependent "on the development of first-class research and technical services based on an excellent educational system." He was referring to Russia's effort, and underlined the relatively high social status of her scientists and the way in which they are organised and assisted to make their full contribution. Such planning of the research effort is lacking here. Sir George Nelson pointed out in his presidential address to the Institution of Mechanical Engineers the appalling waste that exists in the use of engineers, partly due to the latter's inability to organise their work efficiently, partly to the shortage of technicians, which in turn is mainly the result of duplicated effort in manufacturing concerns and research establishments. The duplication of effort results from the need to sustain competition, or the appearance of it. There is no planning within industries (sometimes not even within companies) for the rational utilisation of engineering resources. The expenditure of millions of man-hours on competitive tendering is one illustration of wastage. Many delegates thought the difficulties of getting over this were exaggerated. Clearly the nation cannot afford such a dissipation of effort. What are the gains to the community that arise from such activities? Is not the competition of overseas markets adequate to keep firms on their toes, particularly as the now inevitable (politically) development of the free trade area must bring the challenge right to their doorstep? What is the real cost of duplication of research effort or for that matter of unplanned competitive industrial effort?

A new attitude is needed. Lord Weeks said so with great emphasis in respect of the aircraft industry, when he advocated "rationalisation" into two or three companies—a process quite different from nationalisation, he said, but which the Government must help to bring about. No one could accuse Lord Weeks of socialist tendencies but neither could one call him other than a realist.

In the United States, Dr. King told us, it has been calculated that since the end of the war 50 per cent. of industrial growth has been in the form of products not manufactured at all at the outset. It is further anticipated that in the next six years, 80 per cent. of industrial growth in that country will be in the form of products not yet sold. Dr. King therefore concludes that "the growing points of industry are thus increasingly nurtured by scientific discovery and countries which lack sufficient technical facilities are unlikely to prosper in the international field during the next few decades."

That research pays off is admitted by all large companies, who are now in this country and elsewhere the main contributors to industry's stockpile of knowledge and skills. But few would claim more than a 10 per cent. yield on the number of projects investigated. Perhaps as much as one third flop completely and in their early stages; 50 to 60 per cent. add to the company's knowledge and skills and the remaining 5 to 10 per cent. mature into products. It is therefore useless to set up a research department unless one takes a long view and is prepared for the wastage. This is not the wastage that arises from duplication but the "natural" wastage seemingly inseparable from the nosing out of knowledge in ways in which intuitive genius still plays a big part. But those firms who are most successful with research programmes have a clearly defined managerial policy with respect to them. They understand that time is required to produce results and that much research even when successful does not invariably lead to brilliant new products. Lord Monckton said that about 2 per cent. of our national income was spent on research (about the same as in the United States) but that much of it was on defence requirements in the fields of aircraft, electronics and atomic energy, and the Government bears a greater share of the total than is the case in the United States. Only one sixth of the Government's expenditure on research, which totalled over £200 million in 1955-56, was accounted for by civil research.

The country must find a way of financing research without the compelling force of defence requirements, for, as Dr. King and a number of other speakers said, the real war of the future is likely to be fought out in the primary producing countries of the world with goods and loans, not atomic guns and hydrogen bombs. We must find a way of reducing waste and overlap in various programmes within an industry. Dr. King emphasised the need for "a deliberate policy and good management, and in particular the establishment of good relations between universities, government, science and industry." To achieve this a radical change in attitude is required and in relationships between Government and industry.

THE SPECIALISTS

Twenty-five papers were read in the two main days of the conference, in addition to the opening address of Lord Monckton on the first evening. There was a great deal of variety in the subjects chosen though common threads were discernible here and there. There were four main groups of papers: in the first were those dealing with the subject of research in all or most of its aspects, such as Dr. King's paper on "Research as an Investment," "Research—a Management Technique," by Professor C. F. Carter; "Exploiting the Results of Research," by the commercial director of Fisons, Mr. A. Wormald; and a first-class paper by the Director of Scientific Control of the National Coal Board, Mr. D. Hicks, on "How Operational Research Helps Management." This paper was the subject of many favourable comments in an otherwise critical atmosphere. It was perhaps the refreshingly simple statement of the scientific method and the valuable illustrations of actual problems solved by the Board's operational research team which stimulated and caught the imagination. He brought into his talk no details of techniques or mathematical theories and examples, as is the habit of most O.R. enthusiasts. He classified the procedures of science in seven separate steps:—stating the problem; observing and collecting the relevant data; classifying the data; deriving a theory and mathematical model on the basis of the known information in order to represent the problem under consideration; testing the theory and the solution derived from it, so that exceptions may be identified; formulating a final theory with the controls and forecasting results; and finally, testing the solution. If these main components of scientific research are "clearly comprehended," he said, "and their commonsense element recognised, then the chances that operational research will be given a fair trial are greatly improved."

Among the case studies he cited was one of the relative merits and economics of the different forms of transport systems presently used underground: one of the conclusions was that the life of conveyor belting is not, as was commonly supposed, a factor of wear and tear but primarily one of accidental damage. All the research which had gone into increasing life by the use of harder wearing materials, which had lasted years, was therefore largely useless and was replaced by research to determine a specification for a type of belting with maximum resistance to accidental damage. His last few words are well worth pondering over; they were echoed by several other speakers and had a ring of truth which was generally recognised: "There is a growing conviction that the methods that have proved so successful in the physical sciences can be equally as successful in contributing to the solution of the many difficulties that beset management in all fields."

Continuing **Management**

Weekly Survey

Competitive Tendering

In contrast to Sir George Nelson's remarks in his presidential address to the Institution of Mechanical Engineers, when he emphasised the waste which arises owing to extensive tendering by engineering companies, Sir Arthur Whitaker made a plea for competitive tendering in his presidential address to the Institution of Civil Engineers. There is less conflict of opinion on the matter than might at first appear. Sir George was concerned with the wasted skilled man-hours spent in drawing up tenders which did not succeed.

Sir Arthur is primarily concerned with price. In a sense the difference in attitude between the two is a contrast between the problems of the mechanical engineer and the civil engineer. For those who want to reconcile the two points of view it is possible to say that Sir George is surely right in his argument about waste, but if it is taken too far the argument is a defence of limited tendering and price fixing. Sir Arthur's case has likewise to be accepted in moderation for excessive competition could lead to chaos. Sir Arthur said substantially that if competitive tendering was to become once again normal practice, schemes would have to be worked out more fully before tendering was undertaken, and that the requirements to be fulfilled and the risks to be assumed would have to be defined as closely as possible. In his opinion, it was failure on the part of engineers to carry out these preliminary steps adequately, often excused on grounds of haste, which made contracts placed on a target basis attractive.

Non-competitive tendering is one of the vices of an inflationary age. When there is plenty of work for everyone and it is possible to pass on increases to the ultimate customer without encountering severe resistance it is easier for everyone to make a quick estimate and adjust in the light of experience. It is also a symptom of inflation that more work is put in hand than there are technical people to supervise. Everybody is encouraged to undertake as many schemes as possible, technical ability is spread too thinly over contracts and the situation has begun to develop where those technicians who are available are overworked and only too glad to be able to adjust their figures in the light of results. As inflation proceeds, costs rise and everyone seeks to offset them by increasing turnover as well as putting up their prices. The result is a further attenuation of slender technical resources and so the spiral goes on. It remains to be seen if the deceleration in the expansion of the capital goods industries which is now being experienced makes a useful contribution to reducing haste and also reduces the discount on accurate, careful work. What Sir Arthur has recognised to be a desirable development to restore competitive conditions and increase efficiency may be forced on a large section of the engineering industry by general conditions.

* * *

Design in Engineering

Those companies which have been studying the possible effect of freer trade in western Europe on their own prospects have been impressed in many cases by the opportunity which may develop for high quality engineering products in the sophisticated industrial markets of Germany, France, and the Low Countries as well as in Scandinavia. These markets know a good product when they see one and lower tariffs may give their appreciation a practical twist. Quality in engineering goods is not the same as design, but often it is closely related to it.

Last week, the Council of Industrial Design issued its twelfth annual report. It is apparent from this that although the engineering industry is represented on its council along with the metal fabricating industries, the main progress in the work of the Council of Industrial Design has been among consumer goods industries. This may always be so but it is worth emphasising that design in engineering products may soon be a tactical weapon of unique importance as the selling pace hots up in western Europe.

Many engineering products are entirely functional and will never be anything else. On the assembly side, however, design becomes important in many cases. This is not quite a matter of "dressing up" products or indulging in stream-lining. Good design can mean ease of maintenance. It can also mean less fatigue for operators in an age when management and labour alike are becoming increasingly impressed with the advantages of work study.

* * *

The Third Inflation

To those who suffer from the consequences of inflation and tighter credit, the cause of the trouble may not be a matter of burning interest. Yet, it is important that differences between kinds of inflation should be appreciated for a correct analysis of the causes may give a clearer idea of how long remedial, some might say punitive, measures will be necessary.

The latest exercise on these lines has been done by Professor R. G. D. Allan, Professor of Statistics at London University. Like all those who study human behaviour as opposed to entirely observable facts, he is not sure that he has all the answers. From a study of the statistics of the situation, however, he has decided views on the reasons for the current inflation compared with the two previous ones. There have been three bouts of inflation since the war, he thinks. The two previous ones were due to pressure from raw material prices, the second one being stimulated in particular by the Korean war. Professor Allan considers that the current bout is due to reasons of another kind. In the previous two cases, there was an initial upward surge in prices which tapered off to a period of relative price stability. In the present inflation which developed since the middle of 1954 there has been a steady and persistent rise in prices. His views, tentative though they are, incline in the direction of the current orthodox diagnosis, namely, that the current inflation is due to persistent pressure from wages. He thinks, however, that this may be something of an oversimplification for it naturally leads to the question: why is the demand for higher wages met and why can it be passed on to consumers?

It would seem that the answer to the queries raised by Professor Allan may be answered over the coming winter months. The economy may soon find out whether the point has come when there can be no wage increases because they cannot be passed on to the consumer. It may also find that they cannot be granted because increases cannot be passed on to the taxpayer.

* * *

Programme for Herr Optimist

The most important of the changes in the German Government, so far as British industry is concerned, is Dr. Erhard's promotion. The impresario of the German "miracle" has so far been handicapped in his desire for a free economy by the contrary financial policies carried out by Herr Schaffer. Now, as chairman of the economic committee of the Cabinet, with Herr Etzel, fresh from the High Authority at Luxembourg, as Finance Minister, Dr. Erhard has strengthened his position. He has summed up his policy in the words "Turn the people and the money loose, and they will make the country strong." The Germans have had no cause to complain about the results. Real wages have gone up 60 per cent. since 1950. Unemployment has disappeared. Industrial production has trebled, and exports have increased five-fold since 1948. And the surplus—the German gold and dollar reserves—is nearing six billion dollars.

Dr. Erhard is now preparing to grant some further freedoms to German industry. Not all are equally welcome. He is against cartels, of which Germany is the native land. A bill has now passed the Bundestag making cartels illegal except in times of depression, and for retail price maintenance. The problem of rent control has still to be tackled, but Erhard is planning a German version of the Rent Act. On the industrial front, the chief activity is likely to be the reform of the taxation system. The profits tax is to be overhauled to give companies more incentive to distribute profits. Small savings will be encouraged and income tax simplified. The changes forecast include larger allowances to exempt up to 2½ million people from paying income tax at all, and a standard rate of 20 per cent. on lower and middle income groups. The second largest source of revenue, the turnover tax, which at present operates at each successive stage of manufacture, will be turned into a single phase sales-tax. In the public sector plans are being drawn up to dispose of the state-owned plants. The idea is to sell investment certificates—people's shares—to the public. The most famous concern involved is the Volkswagen works and its great sales and servicing organisation. Just how this will be done or how long it will take to set this particular giant free nobody can say. A general drive is to be launched to get small investors interested in putting their savings into private firms as well as denationalised concerns. A property owning democracy seems to be the next step in freeing the German economy. It is no accident that incentives for the workers are now being stressed. With full employment, rising wages and prices and a flattening of the production curve, the age of "miracles" is over. Nevertheless, Herr Optimist, as the Germans call their Economic Minister, is showing no signs of depression.

* * *

Longer Hours at Volkswagen

It was announced by Volkswagen last week that the workers and management have agreed to work longer hours. Increased competition in the car market from Britain, France and Italy was given as the reason. An agreement of this kind, which is so contrary to the fashionable trend in working conditions cannot be dismissed with the threadbare explanation that Germans work harder than other people. Full employment has arrived in Germany and wages are on the increase. If Germans work longer hours voluntarily at a time like this, there must be something behind the German attitude in management-labour relations which is worth closer scrutiny.

It is true that Volkswagen is a nationalised undertaking and that the workers may be in consequence the more easily persuaded that hard work is not for the benefit of the shareholders. There must, also, however, be a strong sense of loyalty to the company and it is clear here that the German tradition may be significant. German workers in industries which are free from a militant tradition in management-labour relations have a capacity for developing a loyalty and finding satisfaction in their work to a greater extent than in other countries. They more quickly develop a sense of belonging to the group, a sense which helps them to maintain their personal dignity and feeling of importance in their work. This contrast with other countries cannot be pushed too far and it may well come under considerable strain in the next year or so as wage demands from the more highly organised industries are put to employers. Nevertheless, the experience at Volkswagen suggests that people can be persuaded to work harder even in times of inflation when there is an absence of tension between labour and management.

Marketing

ENGINEERING FIRMS IN THE FREE TRADE AREA

13—PREPARING FOR D-DAY

If the inevitability of gradualness ever had a particular application it should be to the development of the idea of the Free Trade Area over the past year or so. The fortnightly series of articles in ENGINEERING on Continental companies in the Free Trade Area began on May 17 and concludes with this, the thirteenth of the series. From one point of view, all that has happened at the diplomatic level since May has been a postponement from July until October of the meeting to consider the working party reports on the Free Trade Area. These parties have been engaged since the autumn of 1956 in working out the basic issues for freer trade in Western Europe. Recently in Paris a meeting of O.E.E.C. at ministerial level set up a steering committee to discuss the basic problems of the Free Trade Area so that in a sense what was originally intended for July has been accomplished in October. From the diplomatic point of view, all that has been gained, as the Irish might say, is the loss of three months. This is gradualness with a vengeance.

If one looks at the inevitability of it all, however, there have been several significant changes in the prospects for a Free Trade Area in the last few months. In the first place the Treaty of Rome has been ratified by the big three potential members (France, Germany and Italy) and only Belgium and Luxembourg have to give parliamentary approval. Short of an international crisis of the first magnitude, the European Common Market (which is likely to be called the European Economic Community) is a fact in Western Europe. Furthermore, again short of an international crisis, the first round of tariff reductions will take place under the treaty in January, 1959, and the first opportunities for industry in the six member-countries to cater for a European as opposed to a national market will have become established. The last few months, therefore, have seen the danger increase that British industry will soon face a Continental industry catering for a very much bigger market, with all the ensuing economies of standardisation and larger scale production which can be translated into price advantages in export markets unless some concept such as the Free Trade Area is established at about the same time as the European Economic Community.

There are indications that the Free Trade Area will not be established without British initiative. On balance, France, Italy and possibly Belgium are opposed to the Free Trade Area idea while Germany and Holland are in favour of it. It is likely that Benelux would not split on an issue of this sort and that Belgium and Luxembourg would line up with Holland. This leaves France and Italy, and there is no doubt that France will require almost as many safeguards to be written into a Free Trade Area convention as it has obtained in the Treaty of Rome. This article is not concerned with the diplomatic tactics of the Free Trade Area but it is important to say in passing that in France at any rate opinion against the Free Trade Area has crystallised as time has gone on. France considers that it will have a big enough task as a high cost producer adjusting its economic and fiscal affairs to the requirements of the Treaty of Rome over the next 14 months without having the added competition of Britain, Scandinavia and possibly Switzerland and Austria to take into account.

HOME DEMANDS

Over the last few months, while this series of articles has been running, opinion in Britain has been slowly crystallising as well. Organised industry has made it quite clear that it does not favour a Free Trade Area at any price. It wants continuing protection for agriculture, "fair trade" regulations as part of the agreement, compensation for industries hit by exposure to Continental competition, a clear set of definitions on the origin of goods and freedom from state subsidies. Organised labour has let it be known categorically that full employment must not be sacrificed to freer trade and that it will not have international commitments on the harmonisation of wages at the diplomatic level handed to it as a *fait accompli*. Any progress on wage and social harmonisation, it insists, must be negotiated between organised labour and organised industry.

When all has been said, however, it is perhaps surprising and certainly encouraging that industry and the trade unions have as yet offered no widespread hostility to the idea of a Free Trade Area. Some trade associations and some unions have expressed alarm in stern tones but the general attitude is somewhere between the fatalistic and the cautiously approving. Much is being said about the Free Trade Area not being accepted only because this country dare not have to compete with a European Economic Community which does not have the Free Trade Area wrapped round it. The fact is, however, that this argument is the final and unanswerable one which may yet have to be brandished in the face of organised industry and the unions.

This series of articles has tried to show that although generalisations about the Free Trade Area are important, its implications vary not only from one industry to another but from one company to another. The series has emphasised that although competition is likely to be keen for many countries, those which are forearmed with information about their competitors' strength and weakness have gone a long way to take advantage of the opportunities which a Free Trade Area offers an enterprising concern. There is, however, still an appalling amount of ignorance about even the more simple issues surrounding the Free Trade Area and the way in which it differs from the European Common Market. Many concerns in the engineering industry are still ill-informed about the implications of both these developments and how they may affect their own future.

MARKET TACTICS

It is vitally important for every engineering company to have exact information on its tactical position on the eve of complete ratification of the European Common Market treaty and the opening of serious negotiations on the Free Trade Area. That company which knows the implications of these international agreements is in a position to take advantage of new developments and to carry out a flexible but aggressive sales and marketing policy. This information is often not available from routine sources in this country. Companies must themselves go and see Continental territories or get their representatives or outside organisations to do it for them. It will be useless to allow policy to be moulded by events when the background of those events is a completely closed book to boards and top managements responsible for evolving company policy.

The issues to be examined for each organisation are exceedingly complex. It is generally true that a company which is efficient and enterprising already, even when its industry is enjoying tariff protection in the home market, will remain efficient when exposed to free trade within Western Europe. There is no doubt, however, that the onset of tariff disarmament will require analysis in advance of a wide range of difficult problems which have to be examined not only in isolation, but also for the way in which they interact on one another. It is possible to set out a list of these points and to indicate a typical industry, which will find each of them of particular importance.

The first is the impact of the Free Trade Area on raw material supplies and prices. Will the Free Trade Area make these more difficult or more easy to obtain, cheaper or dearer? In the case of the iron and steel industry, for example, there is every possibility that prices of materials will rise since, for example, cheap United Kingdom scrap may find a better price if exported to the Continental steel industry.

A second question is: how will prospects in the Free Trade Area be affected by labour costs and availability of manpower? If the Midlands metal-forming industries boom at the same time as motor vehicles and general engineering, how will labour be divided among them? Will it be possible to import labour or even technicians from the Continent? How will a particular concern's competitors be affected by similar problems in certain European countries? Will it be possible to set up branch factories on the Continent and would it be worthwhile going the whole way and establishing subsidiary companies which could develop local goodwill and be better placed perhaps when it came to dealing with the problems of meeting qualifying conditions in certain Continental markets on definitions of origin or for raw materials?

There are issues to be considered on the side of transport if an engineering company is thinking of establishing a new factory with some prospect of developing business on the Continent under the Free Trade Area. Is the attractiveness of East Anglia and some of the new towns increased, since the end product will have a shorter land haul to port of shipment? What are the net advantages of going to the north-east coast which may combine availability of bulky raw materials or semi-finished supplies as well as nearness to port of shipment on the North Sea? These kinds of issue may be very important for concerns making heavy engineering equipment or heavy civil engineering raw materials such as cement.

DECIMAL STANDARDS

There may be a number of critical factors for some companies on the question of international standardisation of units of measurement. Some engineering companies have developed good selling lines over a long period by persuading customers to standardise on a limited range of weights and measurements using, say, pounds or inches. A Free Trade Area may bring increased and successful pressure to standardise on decimal systems, which might be successful over a period of time and so quite destroy the economic scale of operation for British companies no longer able to freeze their customers' business to themselves by means of British weights and measures. A critical decision may be involved here as to whether to change to a decimal system quickly or to wait for a period of time. If it is better to wait for a number of years, for how many years?

Many management structures may have to be overhauled as the Free Trade Area comes in. Sales directors and sales managers who are quite capable of carrying on a well-established policy in well-established markets may not be adequate for opening up the Continental market. Many boards will be faced with the question as to whether old and valued servants of the company shall be retired on generous terms to make way for young men and younger teams which will fight Continental competition in the Home and Continental markets with the same ruthlessness and the same modern selling methods as their German and Dutch competitors will be using.

One of the most difficult unknowns which all companies must face in the Free Trade Area is lack of knowledge about the approximate date when their own particular home tariff will be

substantially reduced or done away with completely. Assuming that the Free Trade Area tariff disarmament schedule is planned to agree with the disarmament schedule for the E.C.M. countries, any industry faces the possibility that its tariff may be cut substantially in January, 1959. In the European Common Market scheme, tariffs are reduced by an average amount every four years but individual member-countries may achieve their average cut either by making a large number of percentage cuts near the average figure or by some heavy cuts and some slight ones. On balance, it seems likely that cuts in this country will be made somewhere near the average (since this is rough justice) and that those industries most able to bear tariff cuts will be the first to have to meet them.

EFFECT OF EXTERNAL TARIFFS

If this is true a wide range of engineering tariffs are likely to come down by the average amount fairly soon, partly to delay the impact of tariff reduction on such weak industries as cotton and paper. If this is so, company boards must plan a policy in the engineering industry which expects the worst and hopes for the best. That policy should be based not only on the impact of reduced tariff protection in the home market but the opportunities which may be growing in the Continental markets due to a similar tariff reduction taking place there at approximately the same time. For example, the reduction in the tariff on Diesel engines in this country may have been preceded by an equal cut in Diesel tariffs in Germany at the same time or at the previous occasion of a tariff reduction or at the next one. Naturally, as time goes on it will be possible to estimate with increasing certainty which tariffs are going to be cut next since all must be reduced to zero at the end of the installation period which may, to judge from present evidence, be spread over 12 to 15 years.

The fact must not be overlooked that although free trade will become established in western Europe, a tariff system will be set up towards the outside world. As is now generally known, the difference between the Free Trade Area and the European Common Market is that whereas the six countries of the E.C.M. will have a common outward tariff, those adhering to the free trade zone will have individual tariff systems outwards. In both cases countries exporting into the Free Trade Area (including the European Common Market) will be at a disadvantage compared with the industries of member-countries since they will have to negotiate a tariff wall which will not exist within the area of free trade. Such countries as the United States and Japan could be seriously affected by this. Some industries devoutly hope that the Free Trade Area will be a fairly high tariff zone to the rest of the world, much to the discomfiture of the Japanese. It is apparent, in any case, that countries outside the zone may at least temporarily have to lose ground to companies within the free zone. Every effort should be made to ascertain where these gaps will appear so that British concerns may fill them. It is almost certain, for instance, that such gaps will appear in certain kinds of machine tools, compressors and certain light engineering products.

There is nothing in the British Government's attitude as it approaches the negotiating stages of the Free Trade Area which is at variance with the position taken up by organised trade and industry on the one hand or by the unions on the other. Those handling the negotiations will demand a free hand on the question of " harmonisation " of wages and will not commit themselves to any formula to be applied by a treaty. They are also likely to lay great emphasis on the importance of " fair " trading provisions so that there is no question of any particular industry being immediately knocked out in the United Kingdom because of double pricing. The British Government is also likely to insist that the tariff disarmament programme shall be worked out in greater detail for the Free Trade Area, covering the whole of the installation period of say 12 to 15 years, than has been the case in the Treaty of Rome which sets up the E.C.M. In principle, the Government will not compromise protection for agriculture, but it is likely that there is some room for manoeuvre among the different countries since most of them wish to protect their own agricultural industries—a fact which leaves scope for give and take.

There is still a certain number of unknowns so far as the Free Trade Area is concerned. Probably the most difficult of all is the attitude of the French Government. When the O.E.E.C. ministers met in Paris last month there was no French Government in office, with the result that the French were not able to take the initiative in a negative way even if they had wished to do so. The French attitude may become more decisive at the next series of top level meetings. On the other hand the solidarity of the six countries composing the E.C.M. may correspondingly begin to break up. There is no doubt that the French, and to a less extent the Italians and Belgians, will want to bargain before they accede to a Free Trade Area being superimposed on the European Common Market. Their argument will be based to a large extent on the problems which they face in adjusting themselves even to the E.C.M. They may plead for time which is, above all other considerations, the one thing which this country should not concede.

Research and Development

TESTING RAILCAR ENGINES

Figures were recently given (see ENGINEERING, July 26, page 117) for the performance of a Diesel railcar set powered by Rolls-Royce engines and using a torque converter drive. Last week an opportunity was given to see the test bed (Figs. 1 and 2) on which the development and proving of these engines was carried out.

The bed is designed to represent a railcar, the engine being slung from an imitation frame, and the loading is intended to reproduce conditions met with in practice. Load is applied to the engine by a Heenan Dynamatic dynamometer of 3,000 b.h.p. capacity driven from the output shaft of the torque converter, and the shaft is continued to drive three heavy flywheels which have an inertia equivalent to half that of the power and trailer coach of a two-coach set. (Only half the inertia, because in the actual sets there are two driving engines.) A high-capacity brake is fitted so that the energy of the flywheels can be destroyed quickly to conform with the loading cycle.

Standard railcar controls have been used as far as possible on the control panel, which is divided from the test-bed chamber by a wall with a glass observation window, and all indicating instruments and gauges are brought out to this panel (Fig. 3).

Three possibilities of control are available: for manual operation, as by a railcar driver; for automatic lockout of the converter unit, with manual rack control—as can be fitted to some sets; and for a fully automatic cycle to reproduce a typical railcar run of 15 minutes' duration. A schematic diagram of the control circuit is shown in Fig. 4. The air circuit section of the control system is unaffected by the three different methods of use. It consists of an engine-driven compressor taking in air through a strainer

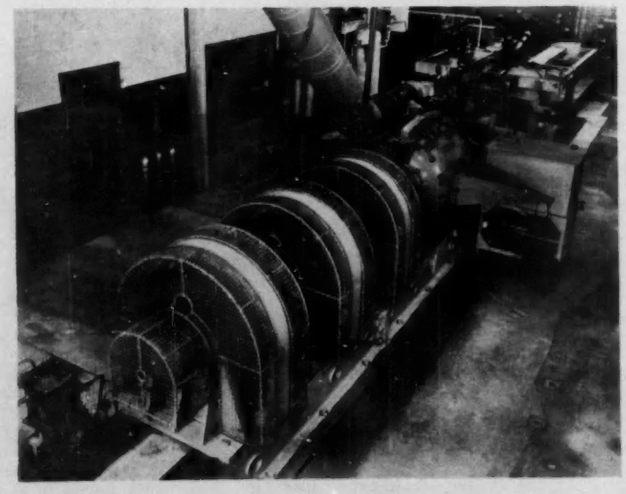


Fig. 1 For testing railcar engines, operating conditions have been simulated closely. The three flywheels imitate railcar inertia.

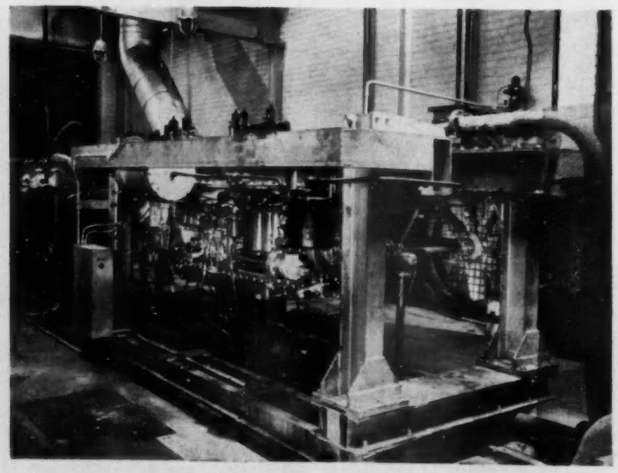


Fig. 2 The 8 cylinder engine with its three stage torque converter is mounted on an imitation car frame. Air to simulate train movement is drawn from outside the building through trunking.

and anti-freezer and passing it via a cooling pipe to a reservoir and also direct to an unloader valve isolated from the reservoir by a check valve. The reservoir, which carries a safety-valve operating at 110 lb. per sq. in., is connected to the main supply line and also to a governor operating the compressor unloader between 100 and 85 lb. per sq. in.

A dirt collector and pressure gauge are provided in the supply line which feeds the converter drive cylinder via a magnetic valve; the direct drive cylinder via a check valve, choke and magnetic valve; and a pressure switch to return the engine from idle when in lockout.

The air supply also feeds the fuel-injection pump rack actuator via a valve controlling the rack position and a check valve and choke to delay any sudden rack opening.

The electrical circuit is basically similar in all three cases but the cam section is isolated by the cam switch when in manual or automatic lockout, and the lockout section is also isolated for manual drive only by the automatic lockout switch.

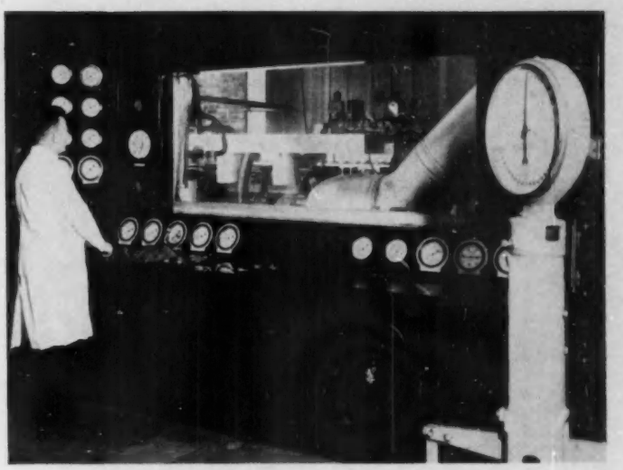


Fig. 3 The control panel is in a separate chamber from the test bed. Standard engine controls as fitted in the cars are used.

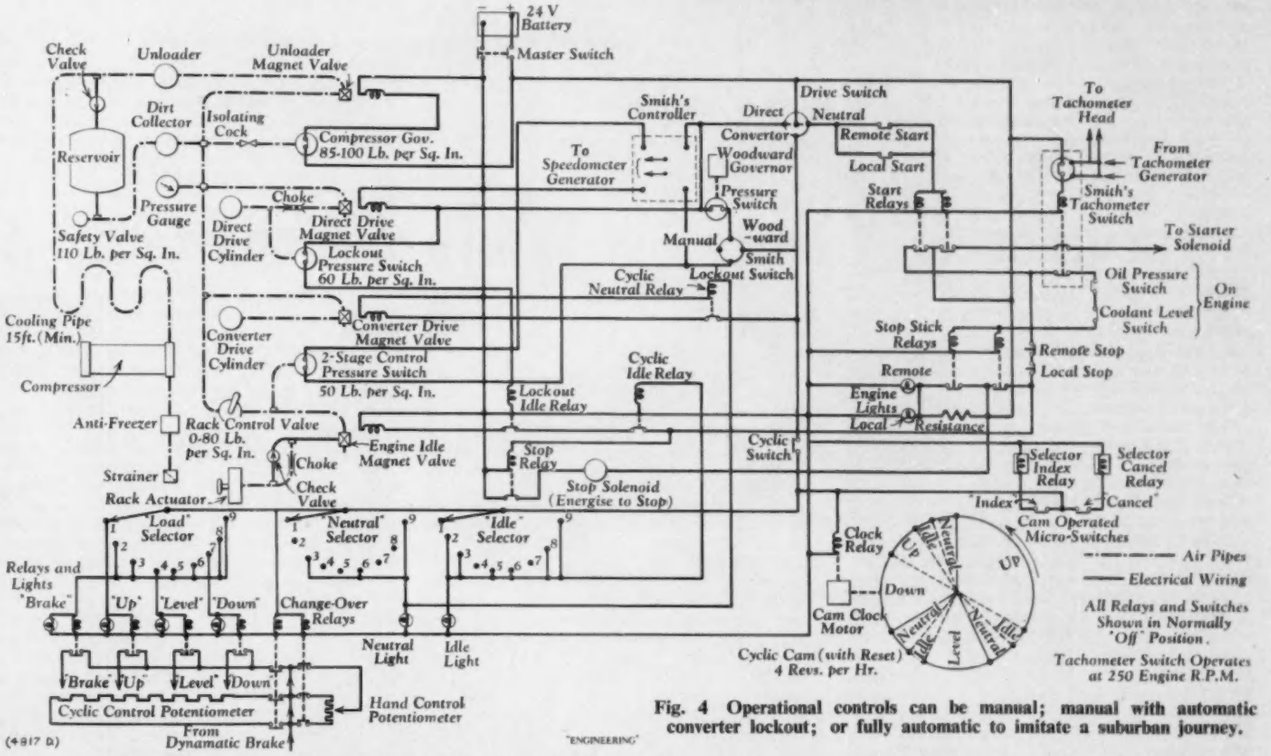


Fig. 4 Operational controls can be manual; manual with automatic converter lockout; or fully automatic to imitate a suburban journey.

In manual operation, current is taken from a 24 volt battery, through a master switch, to the drive switch. The " neutral " position for starting allows current to the starter button. In the " converter " position, the converter-drive magnetic valve is energised via a relay, and air pressure is allowed to operate the cylinder putting the unit into converter drive.

In " direct " position a similar circuit operates to engage direct drive. Current is also supplied to various safety devices and back to a stop-stick relay circuit which, when momentarily broken, energises the stop solenoid, thus closing the fuel injection pump rack and stopping the engine.

The automatic-lockout operation differs from manual operation by the automatic-lockout switch being moved to the lockout position which makes a circuit to the switch operated by a Woodward governor. This switch closes at 1,270 output shaft r.p.m. to energise a relay which breaks the idle magnetic valve circuit and brings the engine to idle, at the same time operating the direct-drive magnetic valve via another relay. The operation of the clutch is delayed by an air choke to ensure that the engine is at idle before direct drive is engaged. This choke also delays the operation of a pressure switch which remakes the idle magnetic valve circuit and brings the engine back to full throttle after a further few seconds delay.

After a drop in output r.p.m. to 1,100 the governor breaks the circuit to the direct drive magnetic valve and the drive immediately returns to " converter."

An alternative method of obtaining automatic converter lockout and lockin is by the use of a Smith's speed-sensitive device which closes or opens a relay to operate the sequence of events as described for the Woodward governor.

When the engine is running under cyclic conditions the lockout circuit is used with the addition of a further system brought into operation by closing the cam switch which, with the drive switch in " converter," supplies current to a clock motor and a telephone-type selector. The motor drives a control cam revolving four times per hour.

The purpose of the cam is the operation of the Dynamatic brake at differing loads corresponding to " up," " level," " down " and " brake " on an actual rail section, and the selection of idle and neutral positions between each stage. The cam carries a series of buttons in positions to give the correct sequence of timing for a 15 minute cycle. This is shown graphically in Fig. 5.

The buttons operate a micro-switch which actuates a three-bank telephone-type selector mechanism. One bank is connected to a set of relays and chooses the correct Dynamatic brake position, at the same time lighting a pilot lamp indicating the choice. The other banks are connected to relays which are energised according to the time-table, and also to similar pilot lamps.

The idle relay breaks the idle magnetic valve circuit bringing the engine to idle, and the " neutral " relay breaks the " converter " circuit, thus putting the torque converter into neutral.

A second micro-switch resets the selector mechanism at the end of each cycle. Position markings on the cam indicate exactly where in the cycle the system is at any time.

The engine can be stopped manually at any position in the cycle. A reset device on the cam allows it to be indexed back to the initial position for starting. An all-speed governor is used in preference to the two-speed type.

The Woodward governor used for operating

Continuing Research and Development

the automatic direct drive is driven from the output shaft. Oil at a minimum pressure of 5 lb. per sq. in. is fed to it from the engine; surplus oil is piped back to the engine sump. The oil outlet from the governor is connected to a pressure-sensitive switch. When the output shaft speed reaches 1,270 r.p.m. the governor opens a valve to admit oil to close the switch; at 1,100 r.p.m. the valve is closed by the governor and the switch re-opens.

Smith's lockout device is an electrical method of obtaining converter lockout and lockin. Speed-sensitive switches are connected to a standard speedometer generator (already in use on railcars for giving car speed). At the axle speeds chosen these switches, operating in conjunction with relays, automatically produce the change into direct or hydraulic drive. The rail speeds chosen when running at full throttle are 37 m.p.h. lockin and 47 m.p.h. lockout, changing to 30 and 40 m.p.h. respectively when running at half throttle. A link between the throttle lever and the control governs which of the speeds is selected. An overlap is included between lockin and lockout to avoid hunting.

In operation it has been found that it is not necessary to engage neutral when the railcars are stationary, but inter-locks are arranged so that the engines cannot be started unless the control is in the neutral position. There is also a link to the deadman's handle, so that should this be released, the engine is automatically put into the neutral position before braking occurs. The test bed applies a very rigorous work cycle to the torque converter which is of the three-stage type and was described in ENGINEERING, vol. 181, page 131, 1956. Although the converter was subjected to extremely arduous conditions during the rail trails, the temperature was never excessive, and in fact, the same converter is now being used on the test bed with a supercharged version of the engine and is still giving satisfactory service.

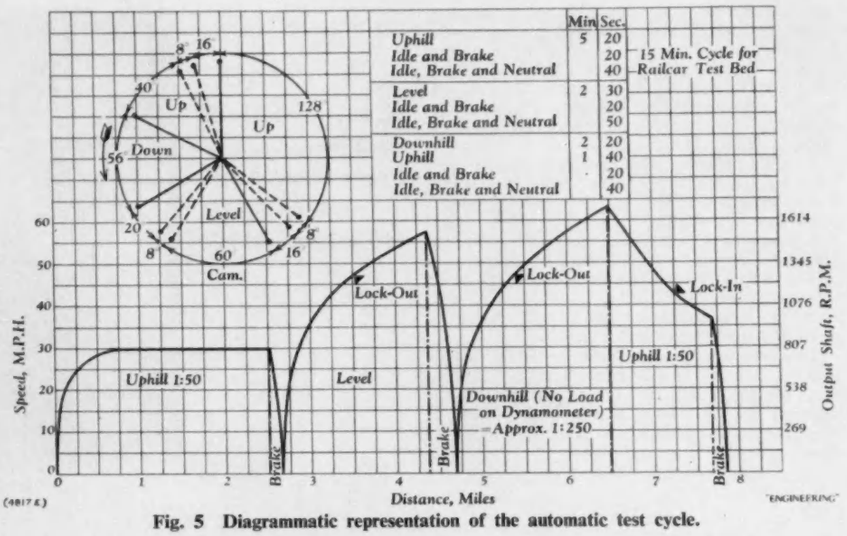


Fig. 5 Diagrammatic representation of the automatic test cycle.

DEVELOPING PLASTICS FOR HIGHER TEMPERATURES

P.V.C. is a brittle material. Small tubes of it snap quite easily. To give it flexibility, plasticisers must be added. With a plasticiser, P.V.C. finds wide application as a flexible cable covering, since it is easy to extrude and resists most forms of chemical attack. The compounded material can also be formed into a useful fabric.

The plasticiser governs the ageing properties of the P.V.C. For, in effect, it dissolves the brittle resin to form a flexible solid solution. If the plasticiser is at all volatile, and most are, it will slowly evaporate and the P.V.C. will return to its original brittle state.

Such an ageing process can be a considerable embarrassment in hot climates. In Middle East oil installations evaporation of the plasticiser can be particularly rapid. The subsequent embrittlement of the insulation causes it to crack off. This results in an increased fire risk.

At the end of the war, Permanoid Limited, New Islington, Manchester 4, started a research programme aimed at producing a non-volatile plasticiser. A range of materials called diolpates is the result of their work. Cables using this material—the "Gulf" range—may be used at their full rating in ambient temperatures of 149 deg. F., whereas early types of cable had to be derated in their current-carrying capacity by as much as 50 per cent. At a reduced rating, Gulf cables can be used in ambients of 167 deg. F.

The company claim that the new cable can be expected to have a life of ten years under tropical conditions that would reduce the life of a natural rubber cable to about one year. Use of the material on small cables raises the cost by about 10 per cent. On larger cables the outer cover contributes such a small proportion to the total cost that the increase is negligible.

In the development of the diolpates various factors had to be considered. The plasticiser had to have good electrical properties, be chemically inert and non-migratory. The last point is of particular importance when such plastics as P.V.C. and polythene are in contact. Many cables have a polythene-insulated core and a P.V.C. sheath: if migration occurs the two stick together.

Diolpates have very large molecules. This gives them their very low volatility. A patented feature of the molecules is the form of the end components. The formula for Diolpate 195 is

$$C_8H_{17}[OOC(CH_2)_4COOC_3H_6]_n OOC(CH_2)_4COOC_8H_{17}.$$

Previous large molecules for plasticisers have been terminated by ester groups. By stopping the carboxyl groups with octyl alcohol, the company get a material with improved electrical performance. The value of n is about 20, giving a molecular weight of about 7,000. Other advantages of this high figure are greater resistance to solvent extraction and non-migratory properties.

To compare the volatility of diolpate plasticisers with other more conventional types, P.V.C. compounds were made up with various plasticisers and specimens were heated in air at 150 deg. C. Table I gives the results. The compounds were made in the following proportions: 100 parts resin (Geon 101.EP), 60 parts plasticiser, 8 parts stabiliser (lead silicate). The specimens measured 4 in. by 0·25 in. by 0·050 in.

To test the resistance to chemicals, the same series of P.V.C. compounds was immersed in a variety of different solvents. The specimens were discs of 2 in. diameter and 0·050 in. thickness. Each was immersed for 400 hours. Table II gives the test results. The physical characteristics of P.V.C. compounded with diolpates are given in Table III, the results being obtained in accordance with B.S. 2571.

At present diolpates are used only for cable coverings. However, they would find application in P.V.C. materials for protective clothing in high ambient temperatures. The material is manufactured by Briggs and Townsend Limited, Manchester 15.

TABLE I.—*The Percentage Loss in Weight of P.V.C. Compounded with Various Plasticisers and Heated in Air at 150 deg. C.*

Plasticiser	Diolpate PPA	Diolpate 195	Diolpate 214	Tri-tolyl Phosphate	Butyl Acetyl-rincinoleate	Di-alphyl Phthalate	Dibutyl Sebacate
After 24 hours ..	0·66	1·6	1·2	3·5	17·8	21·6	5·8
After 48 hours ..	1·16	2·2	1·8	8·1	23·2	28·4	11·7
After 140 hours ..	4·4	4·8	6·1	10·9	26·0	Above 50	Above 40
After 190 hours ..	8·5	7·9	10·4	Above 40	decomposes	decomposes	decomposes
After 240 hours ..	13·2	11·0	17·4	decomposes			

TABLE II.—*The Percentage Change in Weight of Different P.V.C. Compounds when Immersed in Various Solvents*

Plasticiser	Diolpate PPA	Diolpate 195	Diolpate 214	Tri-tolyl Phosphate	Butyl Acetyl-rincinoleate	Di-alphyl Phthalate	Dibutyl Sebacate
Olive oil (B.P.) at 40 deg. C. ..	2·1 loss	4·4 loss	4·1 loss	3·4 loss	18·9 loss	10·5 loss	22·3 loss
Transformer oil (B.S.148) at 70 deg. C. ..	5·8 gain	3·5 loss	0·5 loss	9·7 loss	19·4 loss	20·0 loss	20·3 loss
Lubricating oil (S.A.E.30) at 70 deg. C. ..	0·9 gain	5·4 loss	3·5 loss	8·9 loss	21·0 loss	16·1 loss	22·8 loss
Petrol (Esso Pool) at 20 deg. C.	2·7 gain	2·8 gain	3·6 gain	3·3 loss	19·2 loss	20·0 loss	21·0 loss
Cottonseed oil (B.P.) at 40 deg. C.	1·75 loss	3·7 loss	3·2 loss	2·6 loss	20·8 loss	9·9 loss	22·6 loss
Water (mains) at 40 deg. C. ..	Nil	1·0 gain	0·9 gain	0·9 gain	0·7 gain	1·5 gain	1·0 gain

TABLE III.—*Physical Characteristics of P.V.C. Compounded with Diolpates*

—	Diolpate PPA	Diolpate 195	Diolpate 214
Tensile strength, lb. per sq. in. ..	3,380	3,150	3,600
Percentage elongation at break	250	380	310
Modules at 100 per cent., lb. per sq. in.	2,300	1,800	1,900
B.S. softness, 8 day ..	14	28	28
Specific gravity ..	1·36	1·33	1·33
Cold bend, deg. C. ..	−20	−30	−30
Cold flex, deg. C. ..	7	−2	−2
Volume resistivity, ohm per cm. ..	$0·034 \times 10^{13}$	$0·077 \times 10^{13}$	$0·036 \times 10^{13}$
Break-down voltage, volts per mil. ..	340	350	390

AIRCRAFT ELECTRICS LABORATORIES

In the high-speed aircraft of to-day and, even more, of to-morrow, the electrical supply is a vital service furnishing, in many cases, the basic power source for operating the flying controls and in all cases the radio, radar and navigational aids and automatic pilot, as well as power for hydraulics and other remote control and indicating systems. The electrical system must operate reliably over an arduous range of extreme conditions—altitudes up to 90,000 ft., temperatures from − 60 deg. or lower to + 200 deg. C., relative humidities from zero to 100 per cent. This demands a rigorous development programme and extensive facilities in which to carry it out. Such facilities have recently been put into operation at their Bradford works by the Aircraft Equipment Division of the English Electric Company, Limited; the new laboratories are designed to simulate all the conditions in which the aircraft will be operating.

It is now some three years since the Aircraft Equipment Division was formed, and during that time they have increased their engineering team five-fold and their production capacity has trebled. They produce complete generating systems, control gear and actuators both linear and rotary; in particular, they pioneered the development, in the United Kingdom, of the American Sundstrand hydro-mechanical constant-speed alternator drive (ENGINEERING, February 18, 1955, page 215) which is making possible the evolution of alternating-current systems for multi-engined aircraft with full parallel load-sharing and a consequent saving in weight and increase in reliability

The new development and type-approval test facilities at Bradford, then, include laboratories for the functional testing and endurance-running of actuators, generators and motors, and alternators, as well as high-altitude, climatic, vibration, acceleration and explosion laboratories.

High capacity 30 volt direct-current and 400 cycle supplies are available in every laboratory. In the case of the 30 volt d.c. supply the voltage can be regulated at the particular point of use by a portable regulator. Certain laboratories also have 112 volt d.c. Portable power supplies are available where independent control is essential, including mobile 9 kW 30 volt d.c. mains-operated motor-generating sets and mobile 9 kVA 200 volt three-phase 400 cycle sets.

Shown in Fig. 1 is part of the control room of the dynamometer laboratory in which the flight behaviour of a complete paralleled alternating-current electrical system for a four-engined aircraft can be simulated. This laboratory contains four variable speed drives of 200 h.p. capacity. Each drive is double-ended and is equipped with step-up and reversing gearboxes. Output speeds are continuously variable from 200 to 12,000 r.p.m. using a variable voltage supply from motor-generating sets. Automatic acceleration or deceleration is available at any rate up to 1,200 r.p.m. per second, together with an overall electronic speed control to ± 0·1 per cent. A heated or cooled oil supply is available for four hydro-mechanical drives. Electrical loading facilities are available up to 120 kW and 120 kVAR 400 cycles three-phase; they also provide for hydraulic-drive testing.

HIGH ALTITUDE TESTS

The high altitude laboratory is shown in Fig. 2. Towards the rear in the centre of the picture can be seen the large high-altitude chamber, 9 ft. in diameter and 9 ft. long, in which large generators and alternators, together with their control systems, can be tested at simulated altitudes up to 90,000 ft., over temperatures ranging from − 60 deg. to + 200 deg. C. A drive shaft into the chamber is capable of transmitting 160 b.h.p. at speeds up to 24,000 r.p.m.; and electrical loads up to 120 kW can be imposed upon the machines under test. The critical factor in the high-altitude operation of electrical machinery is brush wear, caused by the very dry air at great heights, and to ensure that the atmosphere within the chamber offers the most adverse conditions, the chamber air supply is passed through a pre-cooler and a bank of activated alumina dryers before passing through a heat exchanger, where it is heated or cooled to the desired test temperature, and from whence it is sucked by vacuum pumps into the chamber.

Fig. 1 The control room for the aircraft system test rig on which a complete alternating-current electrical system for a multi-engined aircraft can be simulated.

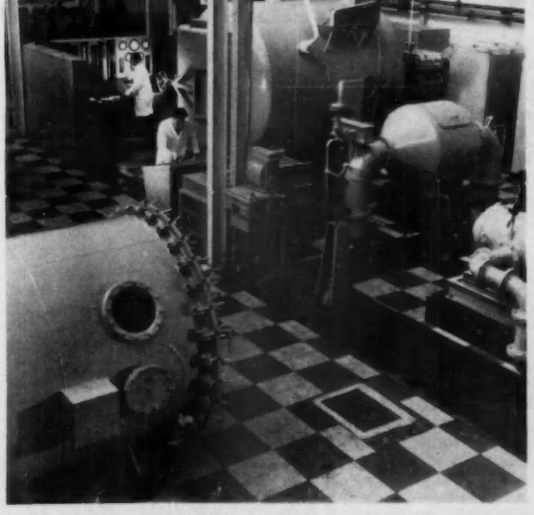


Fig. 2 The high altitude test laboratory. The large altitude chamber and the control panel can be seen in the background.

In the left foreground of Fig. 2 is seen the small altitude chamber, 3½ ft. by 3½ ft., in which aircraft motors and other components can be tested at altitudes up to 80,000 ft. and temperatures down to − 85 deg. C. There is also a sea-level cold chamber where oils and insulating materials, as well as complete components, can be tested at temperatures down to − 60 deg. C.

FUNGUS AND RUST

In the climatic laboratory, aircraft equipment can be subjected to prolonged tests for proving resistance to fungus growth and to corrosion, and for proving satisfactory operation under the most adverse conditions of temperature, humidity, and altitude. In the climatic test chamber, functioning tests are carried out under alternating temperatures ranging from − 65 deg. to + 70 deg. C. at altitudes up to 60,000 ft., and under the conditions of a relative humidity of 100 per cent.

Long-term temperature tests on smaller equipment can be carried out at temperatures up to 200 deg. C. in two large ovens. Resistance to fungus growth is tested in a small humidity chamber representing tropical conditions, + 32 deg. C. and 95 per cent. humidity, using standard cultures of officially-specified fungi; these tests last for 28 days. In another humidity chamber tropical exposure tests, designed to assess corrosion resistance, are carried out over a period of three months, the temperature being cycled daily between + 20 deg. and + 35 deg. C. and humidity being maintained near 100 per cent.

In the vibration laboratory are carried out search tests to determine the natural frequency of the equipment under test, and endurance tests under severe vibration conditions over the full range of frequencies from 10 to 500 c.p.s. The equipment comprises three Moy mechanical tables capable of applying circular vibrations to equipment weighing up to 25 lb. over the frequency range 0 to 150 c.p.s., and one de Havilland moving-coil type linear vibrator capable of testing equipment weighing 120 lb. over frequencies up to 500 cycles per second.

BRUTE FORCE

It is generally the environmental testing rather than "brute force" which searches out the weaknesses in electrical equipment. It is, nevertheless, necessary to ensure that it will withstand the violent accelerations that may be experienced in aircraft manoeuvres, and the shock loads that a heavy landing will necessarily impose.

Another requirement is to check that the equipment is flameproof. All these tests are carried out in a remotely-controlled acceleration and explosion laboratory. Flameproof tests are carried out in one of two explosion chambers, the larger of which has a capacity of 35 cub. ft. An explosive mixture of air and iso-pentane is fed into the chamber and penetrates the component under test. A primary spark is set off in the component, and the mixture inside the component must ignite without igniting the gas in the rest of the chamber, for a successful flameproof test.

For testing that components function satisfactorily during high speed manoeuvres, tests are carried out on a centrifuge capable of applying centrifugal accelerations from 5 *g* to 20 *g*. Heavy landings are simulated in a drop-test rig which provides for vertical accelerations up to 25 *g*.

Book Reviews

ASTRONAUTICS SURVEYED

Realities of Space Travel. Edited by L. J. CARTER. *Putnam and Company Limited*, 42 *Great Russell-street, London, W.C.*1. (35*s.*)

In 1933 a dozen Liverpool residents, headed by a consulting engineer, formed the British Interplanetary Society. The Society grew gradually throughout the thirties but never topped the 200 mark. The percentage of technically qualified members was low and the Society was considered to be very much an outsider by the scientific world in general. Funds were always dangerously low and its publications (a bulletin and a journal) were both small and irregular in their appearance. At the outbreak of war the Society was forced to disband for the duration; in 1940 two new and smaller societies were formed which later joined forces as the Combined British Astronautical Societies. At the end of the war this organisation and the British Interplanetary Society combined under the latter title, and the Society has since made very steady progress—its present membership being nearly 3,000.

The Society's position in the scientific world is now far from that which it occupied pre-war or even in the immediate post-war period. It numbers amongst its members a high proportion of scientists and engineers—some quite eminent in their own spheres—and amongst the subscribers to its Journal are large industrial firms and government departments. The Journal's standard is a high one, and during its post-war existence most aspects of space-flight have been covered by both technical and popular articles. Because of the great demand for back numbers most issues are unobtainable a few months after publication. In view of the lack of good reliable literature on space-flight, the Council of the Society decided to publish a selection of articles from the Journal. This book is the result.

The book is divided into 11 sections: I. Introduction to Astronautics. II. The Satellite Vehicle. III. Interplanetary Flight. IV. Physical Factors in Space-Flight. V. Biological Aspects of Space-Flight. VI. Targets for Tomorrow. VII. The Development of Astronautics. VIII. Establishments and Testing Stations. IX. History of Astronautics. X. The Distant Future and XI. Appendices. These sections comprise a total of 24 papers which are not by any means all on the same technical level. For example, the first section contains five papers which cover all the basic principles of space-flight and the method of operation of rocket motors. All of these papers are written by present or former Chairmen of the Council of the B.I.S. They are "Basic Principles of Astronautics," "The Dynamics of Space-Flight," "Rocket Engines and Propellants," "Mass Ratios" and "The Calculation of Take-Off Mass." All are slightly mathematical but can be dealt with easily by anyone whose mathematical knowledge is on the level of the general certificate of education. At the upper end of the technical scale comes Lawden's paper "The Determination of Minimal Orbits" which deals with the generalised problem of the transfer of a vehicle between two coplanar elliptical orbits described in the same sense about the same centre of inverse square-law attraction. In all space-flight problems the aim to date has been to obtain conditions under which the minimum energy is required for a given manoeuvre, and this is one of a series of papers published in the Journal in which Lawden has given the results of original mathematical work. These papers typify one aspect of the Society's work, which is to further the progress of astronautics. Such a small organisation cannot, of course, hope to sponsor practical work but wherever it can it encourages theoretical work and design studies, and publishes the results.

The Society has always believed in the step-by-step approach to space-flight and has encouraged the study of artificial satellites, in particular the small instrumental variety. Indeed in 1951 when the Second International Astronautical Congress was held in London the Society chose "Artificial Satellites" as the theme and afterwards published the proceedings in book form. Since that time a number of papers on satellites have appeared and, in view of the recent successful launchings by the Russians, Section II of the book will be of especial interest. Under "The Satellite Vehicle" are "Minimum Satellite Vehicles," by Gatland, Kunesch and Dixon; "A Minimum Instrumental Satellite—Now," by Singer; and "Descent from Satellite Orbits Using Aerodynamic Braking," by Nonweiler. The first of these papers is interesting as a comparatively early attempt (first published in 1951) to determine the size of vehicle required to place various sizes of satellite in a 500-mile altitude orbit. The first of these was to carry no payload, i.e., only the last step of the three-step rocket was to be put in an orbit. This would carry no instruments and would be tracked by radar or optically from ground stations. The all-up weight of the vehicle was estimated at just over 16 tons (*cf.* Vanguard, satellite weight 21 lb., launching vehicle 12 tons). The other scheme of interest was a satellite of 220 lb. with a launching vehicle of 90 tons (*cf.* Russian Sputnik I of 185 lb. and launching vehicle estimated at about 80 tons). It must be admitted that these are remarkably accurate forecasts.

Professor Singer of Maryland University is a well-known proponent of the small satellite, and in the present paper expounds on the usefulness of such a project which he dubs MOUSE (Minimum Orbital Unmanned Satellite-Earth). The present satellites and those of the immediate future will burn out as they enter the denser layers of the atmosphere at the end of their life, but many more useful experiments could be carried out if the satellites could be returned safely to earth. Nonweiler deals with this problem and concludes that wings could be used, as a maximum temperature of only 1,300 deg. C. need be reached, and this only at one point and for a short period of time. This problem also arises in the design of the warhead for intercontinental missiles and is certainly not insuperable—as news from the U.S.A. indicates.

Although these papers are taken from a period of 10 years, only in Section VIII, Establishments and Testing Stations, is there any sign of serious dating—indeed, in some places it is clear that the authors have revised their papers in the light of more recent knowledge. The book can be strongly recommended to anyone wishing to obtain a sound background knowledge of space-flight together with a closer study of some of the more detailed problems.

SAPPER STORY

Across The River. By RICHARD JOCELYN. *Constable and Company, Limited*, 10 *Orange-street, London, W.C.*2. (16*s.*)

Those who saw war service as Sappers and, in particular, those who served in field companies and field squadrons, R.E., will be gratified to learn that Richard Jocelyn has put on record, in *Across The River*, an account which typifies their personal battle during the period of the late war, when we were at last thrusting the enemy back.

This account is no historical diary of a factual unit during a particular battle, but rather a narrative binding together the lives of a fictitious band of Royal Engineers in the course of a divisional advance up to and across a river. Though the scene is set in Italy, the obstacles which have to be overcome could equally well have been encountered in any of the war theatres. The common tasks are all there—engineer reconnaissance, building Bailey and folding boat bridges, tank rafting, the construction of culverts, the use of bulldozers and the Sappers' ever-present and unenviable commitment of clearing mines to prepare the way. Even the reader who has no personal experience of these things must sense the atmosphere of suspense and the cold-blooded courage that is required to lie beside a buried mine while numb fingers struggle to disarm a booby trap mechanism. He will share with the Sappers the black frustration which comes near to quenching the will to persevere when enemy action or nature destroys in a moment the work of hours of struggle.

The story is enriched by many personal incidents inseparable from war memories and the tempo befits those periods of chaotic activity during an assault after the relative boredom of training and waiting. Throughout it is clear that while technical efficiency of an engineer unit must play its part in battle, it is the human spirit which is the deciding factor. *Across The River* is dedicated to the memory of two Royal Engineer officers, but it will also add something to the memory of all the Sappers who gave their lives during the 1939-1945 war.

SEARCHING TESTS

Instrumentation in Testing Aircraft. By C. N. JAQUES. *Chapman and Hall Limited*, 37 *Essex-street, London, W.C.*2. (45*s.*)

This is a very excellent book, covering the whole range of instrumentation used in the testing of aircraft, in their prototype and flight testing stage, including static tests on major components, systems and installations. Furthermore, it goes far beyond anything normally used by an airline or private operator. Operational performance, however, would reap the benefit of development by such searching tests as are recommended and dealt with in this book.

The emphasis is on the instruments available to do a job, which are described in detail. The book also gives examples of alternative instruments and methods which cover the same field and gives points for and against using certain equipment in preference to another in given circumstances. It is interesting to note the progressive trend towards electrical and electronic means to achieve greater accuracy and easier readability. In fact, the whole of one chapter is concerned with data transmission and recording, in which modern cathode-ray tubes, servo, and camera techniques are adequately explained.

The inaccessibility of so many components and structures on modern aircraft demands electrical interpretation of physical changes as the only feasible means of doing the job. The small currents almost invariably involve bridge techniques, with or without amplification, which are fully treated.

The rapid rate of development in the whole aircraft field, both in construction and operation, puts a book of this type in danger of becoming out of date within a short space of time. Moreover, new principles of measurement and refinements in their application are constantly becoming available. The writer has obviously had these two points in mind in his overall presentation of the subject, in which he has given much thought to the full coverage of the underlying principles in each sphere, whilst adequately covering the practical application of actual instruments currently available. In other words, it is a book capable of rapid amendment by addition rather than by re-wording.

The inclusion of brief but indispensable data on the technical specification of each instrument at the commencement of its sub-chapter is particularly useful, and in the main no effort has been spared to make the diagrams, whether sectional or diagrammatic, clear and accurate.

Some of the photographs of components, however, have lost character through reduction, and the space so used could perhaps have been more usefully employed by sectional and "exploded" views.

It is recognised that this book is primarily for the research and development engineer, although the mathematically-inclined "production" man could turn many of the techniques to good account for his own purpose. It is for this reason, presumably, that there is little reference to practical installation methods and procedures involved in using the instruments for their intended purpose.

By careful reading and sensible application of the information in this book, much time and money should be saved by avoiding the use of the wrong equipment initially, and having to make expensive changes as the work proceeds, through lack of experience or guidance.

★ ★ ★

NEW BOOKS

Business Charts. By T. G. Rose. Fifth edition. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (21*s.*)

A series of nine articles on business statistics, published in 1929 in *The Times Trade and Engineering Supplement* were the origin of this text-book. Its usefulness has been such that, during the intervening years, it has exhausted four editions and a reprint. The present edition represents a further advancement on its predecessors, the author having introduced a number of recommendations and illustrations which he has found of value in recording business results graphically for company control purposes. Although there is nothing relating to Schlink charts, Lorenz curves, polar, isometric, trilinear or nomographic charts, or to any of the advanced forms of graphics which makes the subject somewhat forbidding to persons not mathematically inclined, the book forms a useful introduction to the art of portraying business facts, figures and percentages in diagrammatic form. Charts dealt with include the Zee, circle, illustration, symbolic, line, bar, band and rate-of-change varieties. A bibliography is included.

Syllabus of Clay Testing. By T. A. Klinefelter and H. P. Hamlin. U.S. Bureau of Mines Bulletin 565. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (45 *cents.*)

One of the services rendered by the United States Federal Bureau of Mines is the identification and general examination of ore and mineral samples. Many of these samples consist of clays and shales and the present publication describes methods of testing them. The various sections into which the brochure is divided deal with such matters as the nomenclature, description, marketing, sampling and the chemical, physical and mechanical testing of clays of all types. A detailed bibliography is appended.

On the Shelf

By Frank H. Smith

The Verein Deutscher Ingenieure, Ingenieurhaus, Düsseldorf 10, Germany, announce a forthcoming *Wörterbuch der Kernenergie* which, if my dictionary has not let me down, is a dictionary of nuclear energy. It is to be English-German, will contain 248 pages, and will cost 23·90 DM with a 10 per cent. discount for members; again, if my dictionary does not let me down. Anyway, it says "VDI-Mitglieder 10 per cent. Preisnachlasz."

The British Interplanetary Society's less technical journal *Spaceflight* has now reached No. 5 and evidently they have had time to assess the quality of their readership. In an article on "The Young Astronaut's Library," W. E. Keswall, suggesting books to give an accurate grounding, quotes Sir Harold Spencer Jones's *Worlds Without End* (English Universities Press, £954). This would be secondhand, of course.

Societies of all sorts seem to go from strength to strength. In announcing the appointment of a new registrar-secretary, the Institution of Metallurgists state that during the retiring man's ten-year tenure (no pun intended!) their membership has more than doubled—from 1,600 to 3,500. Are we getting more gregarious ? Is it due to our technological age ? Do men like letters after their names ? If anyone thinks a society for those interested in aeronautical history should be formed, please drop me a line.

Monday, October 21, was a busy day for the American Institute of Physics. Their new building at 335 East 45th-street, New York 17, was opened and in the afternoon Prince Philip paid them a visit. The Institute is a composite of the American Physical Society, the Optical Society of America, the Acoustical Society of America, the Society of Rheology and The American Association of Physics Teachers.

The Addison-Wesley Newsletter announces two new titles for Spring 1958 (we must get over Christmas first). They are: *Vibration and Impact*, by R. A. Burton, and *Engineering Systems Analysis*, by R. L. Sutherland. The first has been written in the belief "that an understanding of basic principles of vibration (oscillatory phenomena in general) is needed by all mechanical engineering students, regardless of what their special interest may be" and the second "to familiarise the advanced engineering student . . . and to prepare him to face more complex problems and subjects which require continued integration of the knowledge of more than one branch of engineering."

A rather nice gesture is announced in the September number of *Tandemeer*, the news-sheet of the Vertol Aircraft Corporation of Morton, Pennsylvania, U.S.A. A memorial library was presented to the company's engineering library to commemorate Harold Peterson, chief experimental pilot to the Vertol Company until he was killed in January last year. The intention is that all books placed in the Peterson Memorial Library will be given by employees, members of their families and friends of the company and dedicated to a person or persons—living or dead—whom they wish to honour. There will be a suitable bookplate with the dedication inscribed thereon. I wonder if anybody has ever before thought of this variation on tree-planting ?

Does anyone in this country produce printed material in Hungarian ? I ask this because I have just seen a copy of the Hungarian National Library's technical abstracts. These are produced in three different versions: in English, Russian and German, and contain abstracts of outstanding articles from the Hungarian Press. They can be either subscribed to or exchanged (the latter being preferred). Further details can be obtained from Hungarian Technical Abstracts, P.O. Box 12, Budapest 8.

I believe I have mentioned before the representation in this country of the Johnson Reprint Corporation by Academic Books Limited, 129 Queensway, London, W.2. They have just sent me the latest Johnson price list from which it appears that the cost of *Engineering Index* for one year is 75 dols. while if you have 1,500 dols. you can have the set of volumes from 1928 to 1949. Academic Books Limited themselves have issued a publication schedule for the next nine months or so, and there are some fine resounding titles—fourteen of them starting with "Advances in." The series is well known to librarians but it would seem that there may be some difference from the previous year's prices since Academic Books can only give an approximate figure where any is quoted.

Dr. Bin Cheng, of University College, London, has a nice sense of timing. He has sent me a copy of a most useful reprint of a paper by him in *The International and Comparative Law Quarterly*. It is called "International Law and High Altitude Flights: Balloons, Rockets and Man-Made Satellites." The beauty of the thing is that this was originally published in July, 1957, showing first-rate anticipation on the part of Dr. Bin Cheng.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Dust and Fume Control. Air Control Installations Ltd., Ruislip, Middlesex. "Design of Roto-Clone Dust Control Systems"—technical handbook; Amer-Clone dry centrifugal dust collector for large volume of granular dust—descriptive leaflet and specification; Amer-Jet reverse-jet type fabric dust collector—descriptive leaflet and specification. Dusman flue dust collector for grinding, finishing and polishing machines—descriptive leaflet; Electro-Mist oil mist and fume precipitator—descriptive leaflet and specification.

Geared Flexible Couplings. Link-Belt Company, Prudential Plaza, Chicago 1, Illinois. Two shafts are connected by engaging externally-geared hubs, rigidly mounted on the shaft ends, with an internally geared two-piece housing. Four basic applications each in 10 standard sizes: standard coupling for close-coupled direct driven industrial equipment; spacer couplings; mill-motor couplings for use where one or both shafts is tapered; single engagement couplings, used in pairs with a floating shaft for remote connection. Illustrated descriptive brochure with specification.

Blowers and Fans. Air Control Installations Ltd., Ruislip, Middlesex. "Fans"—technical handbook describing standard fan range and adaptation to special requirements. "A Unique Service for the Electronics Industry"—illustrated specification and technical details of small blowers, cooling fans and dust filters. Bifurcator fans for corrosive fumes, hazardous gases, etc.—specification leaflet.

Test Plant Drives. English Electric Co. Ltd., Kingsway, London, W.C.2. Variable speed drives with precise control for such applications as wind tunnels, engine loading dynamometers, aircraft generator and transmission test rigs, ship-tank carriage drives and brake and tyre testing. Technical details of equipment employed with descriptions of actual installations. Fully illustrated booklet PS/130.

Portable Electric Tools. Black and Decker Ltd., Harmondsworth, Middlesex. Portable electric saws, drills, grinding machines, sanding machines, polishers and other tools, for use with wood, cast-iron, copper, lead, breeze blocks, insulation board, plastics, tiles, bricks and other materials. Illustrated catalogues.

Wrought Light-Alloy Material. The British Aluminium Co. Ltd., Norfolk House, St. James's-square, London, S.W.1. Data sheets showing compositions, specifications and mechanical properties of sheet, strip, bars, rods, sections, plate, tubes and hollow sections of aluminium and various aluminium alloys. English and metric editions.

Filters and Air Cleaners. Air Control Installations Ltd., Ruislip, Middlesex. Nylon and pleated glass air filters for electronic applications—data sheet; Cycoil type P oil-bath intake air cleaner—descriptive leaflet and specification; Roll-O-Matic automatic renewable air filter—descriptive brochure.

Compressed Air Equipment. Atlas Copco (Great Britain) Ltd., Wembley, Middlesex. Portable compressors and contractors' tools, rock drills, mine loaders, winches, coal picks, stationary compressors, engineers' tools, hoists, paint spraying equipment—comprehensive illustrated catalogue.

Roof Design Practice. Robertson Thain Ltd., Ellesmere Port, Wirral, Cheshire. "Materials for Covering Uninsulated Pitched Roofs and Walls" and "Roof Venting as a Fire Precaution." Two technical handbooks (the company's "Codes of Practice" Nos. 1 and 4).

Industrial Valves. Cockburns Ltd., Cardonald, Glasgow, S.W.1. Valves for steam, gas, or fluid services—safety valves, relief valves, stop valves, exhaust valves, reducing valves, steam traps and separators. Well-bound comprehensive illustrated catalogue including test data.

Design

MANAGEMENT, LIGHTING AND ENGINEERS

FACTORY LAYOUT AND PRODUCTIVITY

By W. Robinson,
B.SC., A.M.I.E.E., F.I.E.S.

The wide variation in lighting standards to be observed in British factories has already been referred to. This variation is so random and so acute that there is no need for factory visits to be made in order to discover it. All that is necessary is to drive around any industrial locality at night and view the lighting from outside. Extremes of gloom and brightness can be seen often side by side; they appear in factories engaged in similar activities and, as regards plant and methods, show no such divergencies. This variability, however, is a natural outcome of the rapidity with which fluorescent and discharge lighting have changed lighting standards. Those factories whose lighting now shows up so badly would have been considered reasonably well lighted ten years ago, but obsolescence has overtaken them quickly.

In many ways the managements of those factories which now face the need for lighting changes are fortunate in that they can avoid many of the mistakes made by those which took early advantage of high efficiency light sources. We can now see what was out of sight only a few years ago, namely, that the relative abundance of electric light has wider implications than merely raising illumination levels; it entails, in

Concluded from page 630, *Nov.* 15

the clash of colour between filament-lamp light and natural light and also the poor quality of the former. The introduction of " daylight " fluorescent lamps has removed the former obstacle and the improvement in lighting quality through the refined design methods already mentioned has removed the latter obstacle, so that daylight is now an asset to a factory mainly insofar as it is cheaper than artificial lighting. The effect of this is to give artificial lighting a completely new potential role as the main provider of the visual conditions for efficient production with daylight contributing according to its availability.

This conception of " full " artificial lighting is accepted by progressive managements now, but it is far from being generally accepted due to the hangover of the traditional British reverence for natural light and to the notion that glass is still the cheapest form of lighting. Many architects, in particular, consider maximum daylighting to be a *sine qua non*, they also appreciate the architectural merit of glass, and industrial " glasshouses " continue to be built in

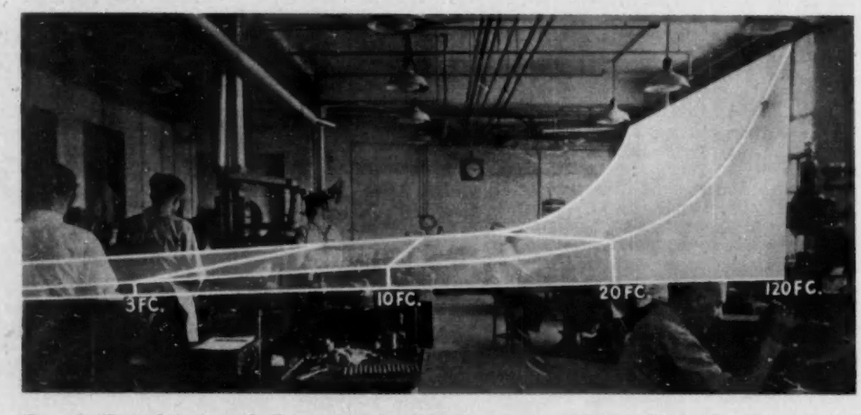


Fig. 16 *Typical horizontal illumination distribution across a workshop from side windows. The variation is masked by the relatively high brightness of the vertical surfaces and can usually be detected only by lightmeter measurement on horizontal working surfaces.*

fact, a radical reassessment of the function of factory artificial lighting, and of its relationship with daylight. The early function of artificial lighting in factories was as a somewhat makeshift substitute for natural lighting, to which it was subordinated. The high cost and poor quality of artificial lighting made it inevitable that it should be used only when production became impossible by natural light and in order to delay this event every device of glazing was adopted. One effect of the rapid rise in the level of artificial illumination is easily seen when it is appreciated that artificial lighting tends to be switched on as soon as it becomes better than the day lighting. Thus lighting of, say, five foot candles would be switched on when daylight fell to about that figure, i.e., when twilight conditions obtained. An installation providing 15 foot candles makes working in such conditions unnecessary and unattractive and the lights would come on at least an hour earlier in the afternoon and go off an hour later in the morning. On dull days, or with poor natural lighting, the tendency would be to leave them on all day. In opposition to this tendency, however, was deplorably large numbers. This is a pity for many reasons. The high building cost of this type of structure usually leads to electric lighting economies, while, to make matters worse, the expanse of non-reflecting glass defeats all efforts to produce comfortable lighting after dark, and if such a factory operates a night shift the situation becomes acute. The glazing imposes a continuous cleaning burden and often admits direct sunlight which, however pleasant, is a visual handicap to production as well as a source of excessive solar heating. Heating costs are seriously increased, and fuel economy is made impossible since the building cannot be properly insulated at reasonable cost. The recent statutory requirements regarding thermal insulation of factory buildings must, in any event, cause serious re-thinking about the glazing of new factory buildings.

The use, or misuse, of side windows is a feature of industrial buildings which needs reassessment on grounds additional to that of thermal insulation. They are usually regarded as convenient means of lighting interiors but Fig. 16 shows how unsatisfactory they may be for this purpose. A failing of windows, which is not shown on the illustration, is that the light is mainly horizontal in direction and vertical surfaces, such as the opposite wall, are so well illuminated as to mask the inadequacy of the working illumination.

Side windows, however, do perform the valuable function of allowing those inside to look out. This link with the world outside is psychologically desirable since it mitigates the mild claustrophobia to which people are prone after long periods indoors, and physiologically because they permit the occupants to extend periodically their range of vision, a valuable eye-resting process. Obviously these advantages apply mainly to small interiors. In large shops most operatives see little of the windows; they can focus virtually to infinity by looking along or across the shop, and there is no claustrophobia. Much of the perennial argument about windowless factories is sterile because it ignores this distinction. Small workshops need windows, not so much to economise on the electric lighting installation, but to allow people to look out; large shops are often better without them. Roof lights, of course, exist solely to let light in. If they give light cheaper than artificial lighting, and without detriment to the latter, then they are worthwhile, but it is wrong to take this for granted.

LIGHTING AND THE INTEGRATED STRUCTURE

The normal procedure for building in this country takes little account of the aforementioned considerations. Structures are designed with great care as regards natural lighting, the glazing for which often supplies the rudimentary ventilation regarded as adequate, and leaves the electric lighting to be added at a later stage. Electric lighting then takes the form of reflectors, often quite unsuitable, suspended, not in relation to their combination with daylight, but according to the location of convenient mounting features. Even concrete structures will often be designed with no provision for lighting fittings, the later addition of which involves much untidy improvisation or chipping of concrete. These and other faults can be avoided by " integrating " the lighting with the structure at the drawing-board stage. This involves the recognition that roof lights are black areas after dark and are the wrong background to electric lights. The search for better roof lights, which show the least black after dark and entail the minimum maintenance, has resulted in an increasing use of monitor roofs (Fig. 17), or saw tooth roofs with vertical or near vertical glazing, to the great benefit of the electric lighting. A particular advantage of vertical roof glazing is that less of the light thrown up to the ceiling by the lighting fittings is lost through the glazing, more being reflected back from the ceiling and this not only improves the interior appearance but also improves the lighting efficiency and weakens shadows. Excessive roof glazing has done more than anything else to delay the use of upward lighting reflectors in industry. Where side windows only are used for natural lighting it is good practice to locate, and group, lighting fittings so that they can be switched in lines parallel to the windows, the distant lines first, and so on, so that the artificial lighting can supplement the window light most effectively and cheaply. There is an increasing tendency to discount side windows altogether as lighting media but to preserve their viewing function in the form of slit windows. Figs. 18 and 19 illustrate another approach to the inte-

gration of natural and electric lighting, where the artificial lighting closely simulates daylighting.

In the United States these finer points of lighting integration are already being by-passed in many plants which place almost complete reliance on artificial lighting. The windowless air-conditioned factory is a special case where daylighting is more expensive in the long run than artificial lighting, but the tendency is for roof lighting generally to be avoided, and for slit windows to superseded high windows. There is little doubt that electric lighting will eventually be the mainstay of factory lighting whether by day or night.

Fig. 17 A monitor roof such as this gives excellent natural lighting without handicapping the electric lighting. Vertical or near-vertical roof lights prevent the excessive entry of sunlight and have the added advantage of self-cleaning qualities.

LIGHTING AND HEATING

Heat is not so much a by-product of electric lighting as its main product. It is usually regarded as a nuisance, and as a factor limiting the illumination which can be provided. Certainly the high-temperature radiation from tungsten-filament lamps can be uncomfortable especially from low-mounted fittings but, nevertheless, there are signs that too little attention is paid to the possibility of converting this liability into an asset. It may seem surprising that a tungsten-filament installation of good quality, i.e. using semi-indirect lighting fittings, giving the recommended 20 foot candles in a general office and thermally insulated to best modern standards, involves an electrical load which is equivalent to the normal heating wattage requirement.

As filament lamps convert 95 per cent. of their energy intake into heat it is clear that this heating contribution should not be ignored. The type, height and layout of the fittings can be such as to prevent excessive radiation at head level and there is no real reason for rejecting this heat output as unusable. The heating benefit normally obtained is small, however, because the electric lighting is subordinated to natural lighting, because separate forms of heating are used during the cold weather, to which is ascribed the full merit, and because adequately insulated structures are still not common.

The introduction of fluorescent lighting, requiring only about one-third of the wattage for equal light output, might seem to diminish the importance of the heat factor, but in practice the reverse is the case. Illumination levels have increased so much that lighting wattages have continued to rise. Furthermore, fluorescent lighting has revealed first-class heating characteristics, so much so that in a number of industrial buildings fluorescent lighting of about 70 foot candles is also supplying a large part of the heating needs. One of these installations consists of cold-cathode fluorescent tubes in perforated aluminium reflector sections which abut to cover most of the ceiling. These reflectors are bonded to the heating pipes of a conventional boiler heating system, which are embedded in the ceiling; the perforations meet the requirements of the ventilating system and perform a useful

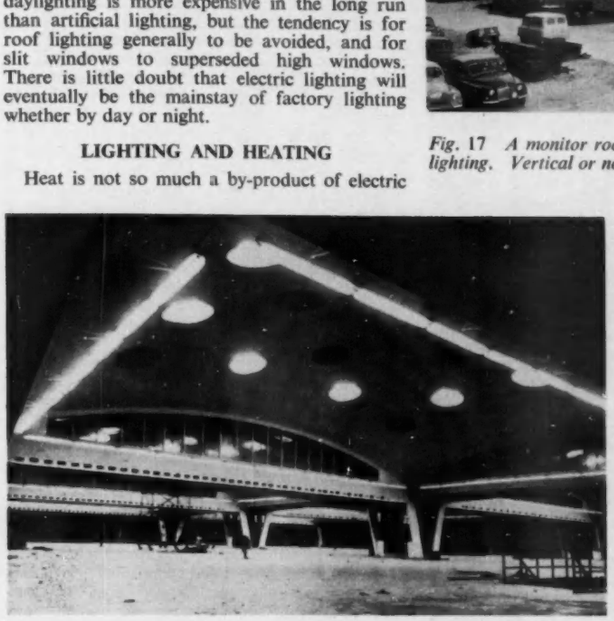


Fig. 18 Effect at night, with full dependence on artificial light.

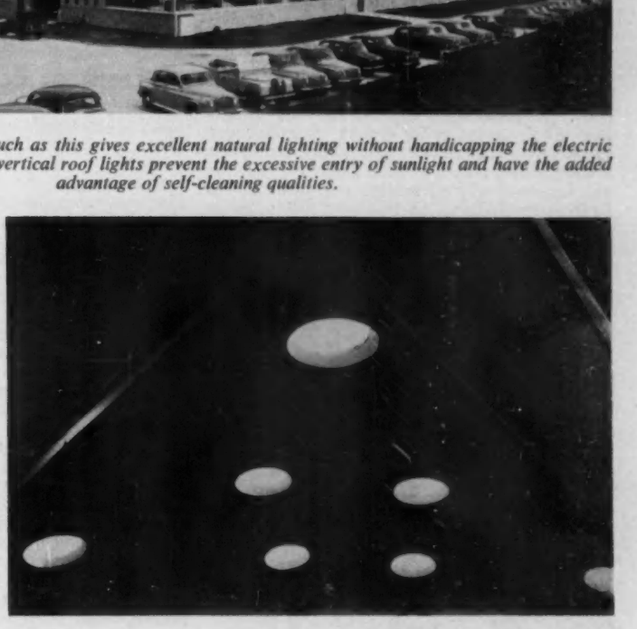


Fig. 19 Daytime effect (note disposition of fluorescent lamps in false ports).

Figs. 18 and 19 In this building the electric lighting is designed to simulate daylight in colour, quality and direction, thus providing a smooth transition from natural to electric lighting.

Fig. 20

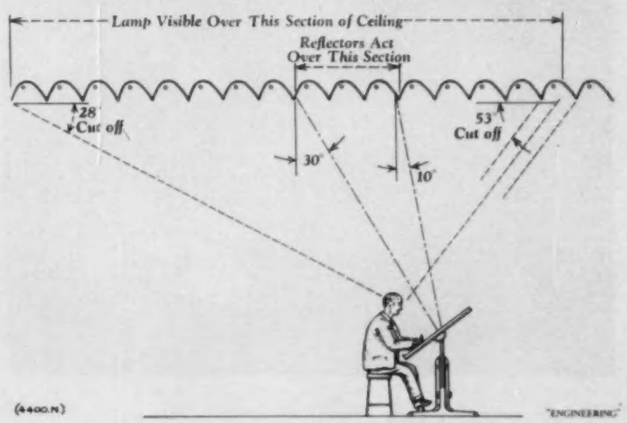


Fig. 21

Figs. 20 and 21 Drawing office lighted by fluorescent lamps against an aluminium ceiling shaped to act as reflector. Diagrammatic cross-section of ceiling showing arrangement of lamps in asymmetric reflecting sections to give minimum glare at the draughting position without loss of lighting efficiency.

Continuing **Design**

acoustic function. The installation represents, in fact, a close approach to the complete integration of environmental services. The boiler heating system is thermostatically controlled, and the heat is conducted to the reflectors which transfer it downwards by low-temperature radiation. When the fluorescent lighting is on, the reflectors absorb heat from the lamps and the heating duty is gradually shifted from the boiler system to the lamps by the action of the thermostats. It would seem that the next logical step is to eliminate the boiler system altogether and to substitute radiant electric heating arranged on a change-over switch or load balancing relay to provide continuity of heating regardless of the lighting conditions. In this way full value is obtained from the lamp heat emission, while the supplementary electric heating makes good any heating deficiencies without incurring additional demand charges. Integration of electric lighting with daylighting, has already been achieved in many buildings, the lighting being controlled by sky-facing photo-electric cells which control the lighting selectively according to the daylight available. Figs. 20 and 21 illustrate a form of ceiling which can make effective use of lamp-heat emission while at the same time giving a desired light distribution.

Fig. 22 For many locations and processes, such as paint spraying, the effect of the nature of the lighting on productivity and quality of output is decisive. In this case flameproof lighting of daylight quality and quantity is provided by fluorescent lamps in a glazed and sealed chamber running the length of the spraying shop.

LIGHTING AND THE ASSEMBLY SHOP

A further stage in integration has been achieved in a new relay production shop also in the North of England. In this shop the lighting is on similar lines to the previous example but the illumination is about 100 foot candles. This shop is fully equipped with conveyors and the interesting feature is that the conveyors have been placed underground, despite added complexity and cost, and despite some loss of flexibility, in order to leave the ceiling clear of obstruction. This is industrial engineering of a high order and emphasises once again the inter-relation between advanced lighting and advanced production methods generally. It is significant that the outcome of this integrated planning is a shop geared to the intensive production of complex assemblies which makes little visible show of the means by which it is achieved and provides a stimulating yet uncluttered environment for the occupants.

It is interesting to see how the march of events is forcing the integration of lighting, heating, ventilation, and acoustics in buildings and the integration of all these services into the overall industrial engineering framework. For thermal insulation to improve, as it must, the area of glazing must diminish. This will involve the use of artificial lighting for long periods in summer as well as in winter and the illumination level will be governed not so much by the requirements of visual tasks but by the necessity to maintain a reasonable relationship with outdoor natural lighting. In such buildings hit and miss natural ventilation will no longer suffice and forced ventilation becomes inevitable since the problem of heat dissipation in hot weather is otherwise insuperable. It is clearly impossible to visualise this kind of structure emerging successfully from unrelated planning of the various services and it is unlikely that the opportunity of incorporating acoustic treatment at the same time will be missed. The result of this co-ordinated effort must suit the requirements of production and this can be achieved only if the co-ordinator in chief is an industrial engineer.

TABLE I.—*Effect of Illumination on Speed and Accuracy of Typesetting*

Test No.	Mean illumination, foot candles	Percentage of daylight output	Errors (turned letters), per cent.
1	1·3	76·0	24·00
2	6·8	88·4	17·56
3	14·0	93·7	12·51
4	13·0	96·7	12·30
5	24·5	100·8	11·28
6	Daylight	100·0	10·48

It is usual to discuss the effect of lighting on production before proceeding to discuss the lighting itself. This order of things has been reversed in the present article because it seems to the author that this procedure implies a wrong approach to lighting at its present stage of development. Lighting plays its part alongside all the other varied and complex features, both physical and psychological, which combine to make a good factory. The urge to provide the best possible lighting within the resources available is instinctive with good management and the reward for the effort is the knowledge that everything possible has been done in this direction to make the plant efficient. It is unnecessary, and indeed usually impossible, to ascribe to lighting alone a definite figure of increase in productivity for the factory as a whole; its contribution is pervasive; its impact on productivity is linked with that of good management, good labour relations, and a cheerful and healthy environment. To say this is not to diminish the importance of its direct contribution to speed and accuracy of work and to the reduction in fatigue and accidents (Figs. 22 and 23); neither is it intended to minimise its great potentialities as a production tool through special lighting applications for work and inspection processes, as depicted in Fig. 24.

TESTS OF LIGHTING AND PRODUCTION

Although the possibility of determining the overall effect of lighting on productivity is remote there can be no doubt of the improvement in production which can be shown to result from improving the lighting of individual processes. Table I shows the results of a test carried out under the auspices of the Medical Research Council on the effect of illumination on typesetting by hand, an operation requiring high visual acuity. Table II shows the results of a test under the same auspices on tile pressing, an operation making no great visual demands. These tests were carried out in the 1930s and each involved at least two years of observations

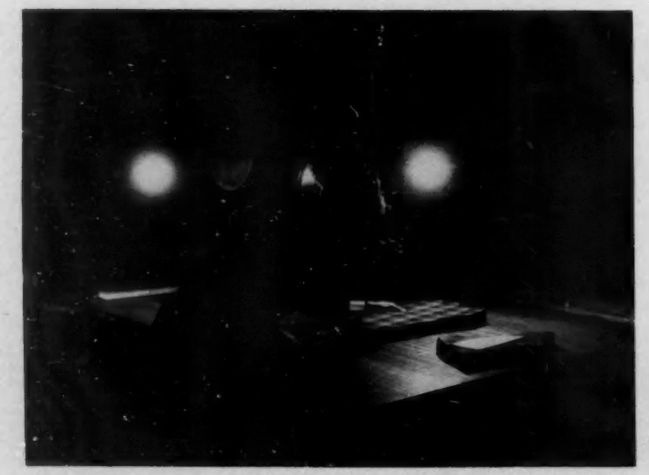


Fig. 23

Fig. 24

Figs. 23 and 24 A serious accident risk is obvious in the darkened workshop due to insufficiently shielded lamps dazzling and confusing the operator and to the hard shadows produced by small lamps. But substituting fluorescent lamps and raising them above the working field of view minimises glare and shadow and produces safe working conditions. Note also improved posture of operative (whose eyes are now several inches higher above the work) thereby reducing fatigue and improving health.

TABLE II.—*Variation of Tile Production with Illumination*

Illumination, foot candles	Average number of tiles per hour	Relative output	Number of weeks in period
0·6	252·3	100·00	25
2·2	267·3	105·90	22½
2·5	273·7	108·08	9
5·8	278·7	110·46	26
6·9	278·7	110·46	26
14·3	284·1	112·60	26

with rigorous control of variables. Such tests cannot be undertaken lightly and these two remain classic tests of their kind. The results indicate that even a small improvement on very low illumination increases individual productivity and quality of output. It is also clear from them that there comes a point, at about 15 to 20 foot candles, where further productive increases, as measured by tests of this kind, become less easy to obtain by raising the illumination.

THE BROADER PICTURE

It is probable that rigorous tests of this type can contribute little more to our understanding of the direct relationship between lighting and productivity, since present day illumination levels are generally adequate for the basic visual tasks and individual performance tests at higher illumination levels are not likely to produce equally significant improvements in quantity of output. Nevertheless illumination levels are rising steadily and 50 foot-candles of general illumination is not uncommon while up to 300 foot-candles of localised lighting is provided for much small assembly and inspection. The reason for this is to be found partly in the availability of cheaper and more acceptable electric lighting and partly in the increasing *tempo* and complexity of production. The most compelling factor, however, is the growing awareness of management that the standard of lighting in a factory is linked with the success of the factory in ways which cannot be measured but can only be experienced. A feature of the well-known Hawthorne investigations carried out in the United States by Elton Mayer on environmental factors in industry was the surprising result of changes in environment, particularly of the lighting. After output had risen substantially as a result of improvements in the lighting it was decided to test the effect of reverting to the former state. The outcome was unexpected, production did not fall back but went on increasing. This would seem to be excellent ammunition for those who claim that there is no advantage in exceeding a medium standard of lighting, and that the workers' output depends so much on other factors, such as monetary incentives, work study, and the like that the effect of environment, and even of work lighting, is marginal. Such a conclusion, however, ignores the fact that the rise in output was set off by the lighting improvement, and is unlikely to have occurred in the first place without such a change. It is not suggested that some other change would not have had a similar effect, but when all else has been done to make a factory efficient there still remains this extra stimulant to production. A more convincing explanation of the result of the Hawthorne test is that the increase in output had a psychological basis, a stimulus was imparted to work, a new *tempo* was achieved, and this *tempo* survived the subsequent reversion to former conditions.

In the end the lighting of a factory must be judged, not by a lightmeter, but by how it affects the workers in the factory. British industry is learning the hard way, that factories house people as well as machines and that when all is done, when every technological resource has been applied to increase production, it is still the workers' state of mind which regulates the *tempo*. Factory lighting in general has a long way to go before it qualifies in this respect, that is, before it becomes a major environmental factor in production.

* * *

NEW 33 KV CABLES

British Insulated Callender's Cables, Limited, Norfolk-street, London, W.C.2, have developed a ductless shaped-conductor oil-filled three-core cable (to be known as the D.S.O.) together with a range of joints and terminations, which satisfy the Central Electricity Authority's requirements. It is intended for use at 33 kV.

The use of shaped cores enables the free space to be utilised for oil flow. It has therefore been possible to omit the metallic spiral ducts and paper fillers employed in circular conductor cables to support the sheath, while the oil volume is also less. Both these factors have helped to lower the cost.

The new cable is available with either copper or aluminium conductors in the range from 0·2 to 0·6 sq. in.; and can be supplied with either lead or seamless aluminium sheaths. Anti-corrosion protection is achieved by an overall serving.

The new cable is designed to operate at the maximum conductor temperature of 85 deg. C., which has been accepted as standard for oil-filled cables in this country for several years. The current ratings are similar to those of equivalent circular-conductor oil-filled cables and are some 20 to 25 per cent. greater than those of equivalent 33 kV solid cables, which possess voltage limitations and are prone to ionisation and deterioration of the dielectric.

FORCED AND SELF-EXCITED VIBRATIONS

A Review of this Year's Thomas Hawksley Lecture

Industrial applications of vibrations in mechanical engineering were surveyed in the 44th Thomas Hawksley lecture given by Professor J. P. den Hartog to the Institution of Mechanical Engineers last Friday, November 15.* Professor den Hartog is Professor of Mechanical Engineering and head of the department of mechanical engineering at Massachusetts Institute of Technology. In the 1920's he was assisting Professor Timoshenko at the American Westinghouse Electrical Company, and later became Assistant Professor at Harvard University.

The importance of vibration in high-speed machinery was beginning to be recognised after the first world war. Professor Timoshenko's book *Vibration Problems in Engineering* appeared in 1927 and was followed by Professor den Hartog's *Mechanical Vibrations* in 1934. These two books greatly enhanced the literature and have become standard works.

The lecture is a fascinating outline of the historical development and of the present state of the art in mechanical engineering in its broadest sense. Tribute is paid to Lord Rayleigh's *Theory of Sound* and Routh's essay "The Stability of a Given State of Motion," both of which first appeared in 1877, the former establishing the most important facts and theories bearing on all vibration phenomena in mechanical engineering and the latter laying the mathematical foundation to the theory of dynamic stability.

The topics of the lecture are appropriately divided by Professor den Hartog into two distinct groups: forced and self-excited vibrations; both groups are illustrated by a large number of actual cases, each a well-told story in itself. The phenomenon is described, the principle clearly explained and the solution given according to the present state of the art.

* The title of the lecture was: "Vibration: A Survey of Industrial Applications."

The forced-vibration group begins with balancing, dealing with reciprocating engines and turbine rotors, vibration of turbine blades, longitudinal and torsional vibration of shafting, anti-roll devices for ships and the calculation of natural frequencies. The self-excited vibration group deals with vibration excited by dry friction, oil whip, and by leakage through labyrinth seals, flutter and stall phenomena, vibrations arising from Kármán vortices, shimmy and instability of combustion in rocket engines.

SHAFT BALANCING

On the subject of balancing the lecture is mainly concerned with large turbine rotors, which are usually corrected to the limit of the accuracy of the balancing machine. This is usually less than 2 in.-oz., and is equivalent to a displacement of the centre of gravity of the rotor of less than 10×10^{-6} in., compared to the displacement which will cause the rotor to jump on its bearings of 4×10^{-3} at 3,000 r.p.m. Thus, the shop unbalance is usually well within that required to overcome gravity.

However, turbine rotors can go out-of-balance, due to transient thermal gradients in the rotor body caused by the rotor lying stationary in the hot casing and bending due to the temperature difference between the top and bottom of the rotor. For example, in a recent paper* it was shown that a 5 ton rotor of 9 ft. span would be displaced 0·004 in. by the bend produced by a top to bottom temperature difference of 12 deg. F. As referred to above, this displacement would produce an unbalanced centrifugal force at 3,000 r.p.m. equal to the weight of the rotor. To overcome this it is standard practice to turn the rotor over at slow speed before putting it into operation.

* N. Elce, "Economic Basis and Character of Steam Turbine Design," *Proc.I.Mech.E.*, vol. 70, No. 32 (1956).

The paper just referred to also gives examples of the possible cause of bending of turbine rotors, as arise from asymmetric relief of a shrink-fit stress on gland sleeves and the wheels of built-up rotors, and Professor den Hartog gives further references to cases where the hump of the distortion slowly wanders through the rotor. In addition, Professor den Hartog gives an account of a curious case of heat-distortion vibration. The central hole in the rotor had been drilled a shade off centre and a small quantity of cutting fluid had been inadvertently left in the bore before it was sealed up. On account of the eccentricity of the bore, this fluid had collected by centrifugal force on the off-set side leaving part of the bore periphery dry. The high temperature boiled the fluid in the off-set side of the bore, extracting heat from the rotor by the boiling process on that part of the periphery, causing it to bend and vibrate intolerably. When the cause was ultimately discovered and the fluid drained off, the machine performed satisfactorily.

When balancing marine propellers, attention is drawn to the importance of an unbalanced thrust in comparison with mechanical unbalance. In a large propeller with a rating of 25,000 h.p. at 100 r.p.m., mechanically balanced to 20 in.-oz., the centrifugal force at service speed is 0·4 lb. The thrust force of the propeller at 20 knots is approximately 100,000 lb. per blade of a four-bladed propeller. If one of the four blades has an angle of attack differing from the other three by 1 per cent., or approximately 0·04 deg., its thrust will be off by 1,000 lb. This unbalanced hydrodynamical force acts about the same radius as the unbalanced centrifugal force of 0·4 lb. Professor den Hartog justifiably refers to the balancing machine in this instance as a fine toy, as harmless as a 10 decimal place calculating machine applied to physical quantities subject to 10 per cent. errors.

Longitudinal and torsional vibration of ship's

Continuing Design

shafting is also discussed. The former can occur in ships with long shafts, and is excited by the variation of thrust of the propeller, the thrust block being the nodal point. Such longitudinal vibration was first investigated by the British Admiralty, though Professor den Hartog refers only to American papers on the subject. All investigators are unanimous, however, as to the remedies where resonance occurs. These can concern a change in the number of blades or the location of the thrust block. Another method, devised by the Admiralty and Michell Bearings Limited, Newcastle-upon-Tyne, is the introduction of damping at the thrust block by floating the thrust ring carrying the pads in oil.

Torsional vibration and its practical solution has been well covered by Ker Wilson; his two volumes have become standard works. In particular the 1956 edition of his books covers a wider range of experience than the earlier edition, yet Professor den Hartog still manages to add the hitherto unknown story of the Liberty ships of the last war; these ships were engined by triple-expansion steam engines built in the United States from drawings of a successful design made in 1916, dusted off for the occasion but not checked for torsionals. They served that purpose adequately during the war but on their speed being raised for commercial service after the war their propellers started to fall off due to running on a torsional critical. Professor den Hartog recalls that damping in an engine is so complicated that resort still has to be made to empirical rules based on statistical experience.

TURBINE BLADING

The lecturer gives a very clear history of turbine-blade vibration, although it is based on American experience. The first important possible resonances are those due to what is known in this country as diaphragm impulse resonance. This is due to resonance of any mode of the blade or group of blades with the impulse from the wakes streaming from the proceeding guide vanes. This usually concerns the higher modes which, although they may be difficult to excite, sometimes fail at resonance because of the intensity of the excitation.

Lower modes are usually affected by non-uniformities in the steam or gas flow. In this case the excitation is of low intensity but, on the other hand, the lower modes of the blade vibration are quite easily excited because of the low damping giving a magnification of excitation a hundred-fold or more. Thus, as the lecturer points out, if the amplitude of steam-pressure distribution were to be 1 per cent. of the mean, the alternating stress at resonance would be equal to that caused by the full steam pressure and this in combination with the steady centrifugal and steam-pressure stress might well fatigue the blade to destruction.

Fatigue of steam-turbine blades can arise from repeated shocks received on entering and leaving the partial admission zone of the turbine. American tests have shown that the damping of the blade is so small that the vibration scarcely diminishes during the passage of the blades through the no-admission zone and that, statistically, some of the blades will receive these repeated shocks in the right phase to become additive. The trouble is overcome by making the design very conservative, rounding of the edges of the nozzle and employing an alloy steel which has a higher internal damping than the steel previously used.

The lecturer describes some of the methods suggested for introducing damping but concludes, quite correctly, that no really good solution has been found to the problem. The application of lacing wires in packets of blades is of value in avoiding certain modes of vibration, but tuning blades to avoid some of the higher modes is still quite an art.

On the calculation of natural frequencies Professor den Hartog points out that a revolution has been brought about during the last decade by the advent of the electronic computer. Dynamic systems are no longer simplified when a computer is available and a number of design variations can be incorporated in the programming of the computer operations.

This works beautifully for many problems such as the vibrations of multi-bearing turbine rotors and discs. However, the lecturer should have pointed out that for the very long last blades of large steam turbines all the stiffness and mass criteria cannot be expressed exactly and that it is still necessary to make full-scale models and test experimentally. This is quite a simple thing to do and is the best practice. It is, however, an interesting comment of Professor den Hartog that the relaxation method of calculation does not seem conveniently amenable to computer programming for certain calculations.

COMPRESSOR PROBLEMS

Blade vibration can arise in axial-flow compressors due to stall phenomenon. This has become a very serious problem and much work has been done on it both here and in the United States during the past decade.

When a multi-stage compressor is reduced in speed the angle of attack on the blades increases at the inlet and decreases slightly at the outlet. Thus, at low speed the early rows of the compressor stall. When an isolated blade, set at the proper angle of attack, vibrates, it tends to be damped because a downward motion is opposed by a greater lift force created by the vibration. Similarly, an upward motion is met by a smaller lift force so that the excess part of the lift always opposes the motion and the vibration is damped down by air damping.

On the other hand, when the blade is just stalled, the flow breaks loose from the aerofoil and the slope of the lift curve becomes negative and the conditions are the reverse of the previous case. Thus, vibration can be sustained in the stalled condition and there is no air damping. This is known as stalled flutter and the mode of vibration is usually fundamental bending.

When a row of moving blades in an axial compressor stalls it is usual at the beginning of stall for the blades to stall in separate areas around the blade annulus. This creates a phenomenon known as rotating stall, which arises thus: when a stall patch occurs in some one area the flow is blocked in that area and so the approaching air flows round the obstacle. This changes the incidences on the adjacent blades, reducing the incidence in the direction of motion and increasing the incidence of the adjacent blades in the opposite direction, so causing these latter blades to stall. The stall patch, therefore, travels in the direction opposite to that of rotation relative to the rotor at roughly half the speed of rotation. The number of stall patches increase as the blade row goes deeper into stall. Thus, an individual blade in the case of rotating stall will be alternately stalled and smooth in rapid succession, and Professor den Hartog is inclined to the view that such instability as the stall itself might cause, will not persist long enough to build the vibration up to a large amplitude, and during the subsequent period of smooth the motion will be damped out. It is to be noted, however, that this could also have been said about partial admission.

Tests in this country have shown that where the impulse from the rotating stalled patches coincide with the fundamental blade frequency, failure can occur due to resonance. This has been discussed in a recent paper to the Mechanicals by Carter and Kilpatrick.* The condition is worsened by the fact that air damping may not be of great assistance at this stage and it certainly is negative when the blades are completely stalled. Professor den Hartog concludes that rotating stall sets a limit to the compression ratio that can be built into a single-axial compressor, and all are agreed on that.

Another blade vibration problem is that of singing ship propellers, which manifests itself by a loud penetrating noise. This is caused by some sort of self-excited motion in one of the higher modes of the propeller blades caused by the water stream. It is interesting to note that, although the exact mechanism of the phenomenon is still uncertain, the satisfactory practical cure developed in this country in 1939 by the workers mentioned in the lecture is still the most effective; the most recent case of its application is that of the propellers of the Royal Yacht "Britannia." The method consists of sharpening the leading and trailing edges of the blades, to create hydrodynamic damping and to correct, if possible, the hydrodynamic unbalance referred to earlier.

The lecturer describes the history of classical wing flutter and his references are entirely American. No history of wing flutter should be complete without reference to the work of Duncan, Fraser and others in this country whose work is reported in the Reports and Memoranda Series. This work goes in parallel with that reported in the N.A.C.A.

Still on turbine rotors, Professor den Hartog discusses oil whip. The simple explanation is that the force of the oil film of a rotating journal is not coincident with the line of eccentricity; hence, when the journal is whirling, the centrifugal force which is in line with the eccentricity is not balanced, and the component of the bearing pressure force perpendicular to the centrifugal force or eccentricity tends to excite the whirl. In general, slow rotation and fast whirl is stable and conversely fast rotation and slow whirl at a low natural frequency is unstable. The full theory is still somewhat doubtful but the experimental evidence is satisfactory. At a running speed equal to about twice the critical speed vibration occurs if a full 360 deg. bearing is used. On the other hand, experiments have shown that pivoted pad bearings are completely stable as far as oil whip is concerned; each pad provides its own separate oil film and a supporting force. Thus, simple round bearings with axial slots and separate oil inlets can be made to do the same thing and such bearings have been used successfully to prevent oil whip. It is therefore not necessary to use pivoted pad bearings as the lecturer suggests.

The use of ball and roller bearings in aircraft jet engines is not due to a fear of oil whip, but is because of their smaller frictional loss than arises in high-speed film-lubricated bearings.

VIBRATING STRUCTURES

Vibrations arising from Kármán vortices shed from structures are discussed quite fully. The frequency with which these eddies are shed from a fixed cylinder is about 22 per cent. of the ratio of the stream velocity to their diameter. This frequency is called the Strouhal frequency. If the cylinder can vibrate and has a fair amount of damping the vibration only becomes important when the Strouhal frequency of eddy shedding coincides with the natural frequency of the structure, and resonance takes place. However, in this country, Scruton has shown that with circular steel chimney stacks having very small damping, the vibrations of the massive chimney controls the frequency of the eddy shedding and, in such circumstances, vibration can take place at frequencies up to twice the Strouhal frequency, the instability region decreasing with increased damping.

The failure of the Tacoma bridge is also described. Under a side wind of 42 m.p.h., the bridge became unstable torsionally and vibrated to angles of distortion up to $\pm$ 45 deg. It is now believed that the cause was attributable to Kármán vortices coming off the sharp top and bottom edges of the vertical flange facing the wind. In the reconstructed bridge the solid flanges were replaced by open trusses and longitudinal slits to let the wind blow freely through the structure and to prevent pressure differences arising between the top and bottom of the bridge decks. The structure was stiffened torsionally 100 times, thus raising the torsional natural frequency well above the Kármán

* A. D. S. Carter and D. A. Kilpatrick, "Self-Excited Vibrations of Axial-Flow Compressor Blades." *Proc.I.Mech.E.*, vol. 171, No. 7 (1957).

frequency at any wind speed which can conceivably be expected.

The lecture describes anti-roll devices for ships, the most successful being the Denny Brown system, and on shimmy the experiences described are extremely interesting. Professor den Hartog's clear exposition of the mechanism of the operations is worthy of special study.

The problem of instability of combustion in rocket engines, particularly those of large size and thrust is illustrated dramatically. Combustion is a function of ambient pressure, a fluctuating pressure therefore causes a fluctuating combustion and consequent gas production and hence a fluctuating pressure again. This feedback mechanism can become unstable if certain phase relationships occur. In large rockets, the phenomenon can start suddenly without warning giving rise to pressure fluctuation of high frequency in the combustion chamber, causing failure in a fraction of a second.

REACTOR INSTABILITY

In the field of nuclear power, Professor den Hartog refers to an instability which arises in boiling water reactors. The water acts as a moderator such that the atomic fuel will react and generate heat only when it is surrounded by water and die out immediately in the absence of water. In proper operation, the atomic fuel is surrounded by water with a uniform distribution of small steam bubbles. If the fuel momentarily reacts more vigorously than normal, more of the surrounding water will boil off to steam, so causing the reaction to slow down. As the steam rises water rushes into its place reviving the reaction intensity and so on. Instabilities of this type have been observed and are of considerable magnitude.

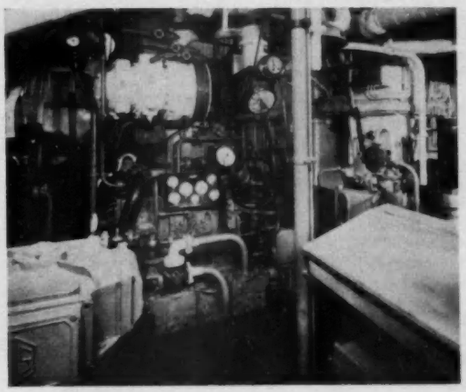
MOTOR TRAWLER "BOSTON VANGUARD"

The firm of Vosper Limited, of Portsmouth, while best known as builders of speedboats and small high-speed naval craft in which they specialise, are also builders of trawlers, and have recently completed for the Boston Deep Sea Fisheries, Limited, the motor trawler "Boston Vanguard," illustrated herewith. She is intended for fishing in the "Middle Waters," and has been designed on lines produced by Monsieur E. R. Gueroult, A.M.I.N.A., who has been responsible for the design of many noteworthy French trawlers.

The Boston Vanguard has a length overall of 126 ft. 6 in. and between perpendiculars of just under 108 ft. The breadth moulded is 25 ft. and the moulded depth 12 ft. 9 in. The hull is all-welded steel, with a wheelhouse of aluminium alloy, in which are, in addition to the customary wireless equipment, etc., a Marconi "Fishgraph," providing a paper record of shoals detected by the "Fishscope," which indicates their presence on a cathode-ray screen.

The fish hold, lined with Onazote and timber, has a capacity of 6,750 cub. ft. It is divided into 24 pounds for select fish, 22 for bulk fish, and stowage at the forward end for ice. Farther forward are two liver tanks, with a combined capacity of 400 gallons, and stowage for nets and bobbins. Oil fuel is carried in three tanks, one to port and one to starboard in the engine room and one in the double bottom, holding in all 51 tons. Fifteen tons of fresh water are carried in the double bottom under the after half of the fish hold, and 11 tons of water ballast under the forward half of the hold.

The motor trawler "Boston Vanguard" is intended for fishing in Middle Waters.



The engine room looking aft showing main engine control position.

Accommodation is provided for three officers (captain, mate and engineer) and a crew of 13. The messroom, galley, washplaces, etc., are arranged on the main deck, as also are the engineer's cabin and berths for four men. The mate and the rest of the crew berth aft on the deck below. The captain's quarters are in the superstructure, abaft the wheelhouse.

The main propelling engine is a Mirrlees KSCDM six-cylinder unit, fitted with a Brown Boveri exhaust turbo-supercharger and rated at 675 b.h.p. at 250 r.p.m. It is cooled with fresh water, normally supplied by pumps driven from the engine, but an electrically-driven standby fresh-water pump is also fitted, with a capacity of 32 tons per hour. Lubrication is on the dry-sump system, and there is also a standby oil pump, electrically driven, with a capacity of 4,800 to 6,000 gallons per hour. There are separate service fuel tanks for the main and auxiliary engines, which can be topped up by a semi-rotary hand pump, and a Mirrlees "Imo" fuel transfer pump, electrically driven, is fitted for bunker fuel-transfer purposes.

At the forward end of the engine room are two Russell-Newbery generating sets, of 20 kW capacity at 220 volts, direct current, one of which drives also an air compressor, delivery 18½ cub. ft. of free air per minute at a pressure of 350 lb. per sq. in. The other set drives a general service pump, with a capacity of 25 tons per hour against a head of 30 ft. In addition, there is an electrically driven Hamworthy standby general service pump, with a capacity of 30 tons per hour against a head of 45 ft., and an auxiliary air compressor, driven by a Lister engine, which will deliver 6 cub. ft. of free air per minute at 350 lb. per sq. in.

Also at the forward end of the engine room, on the starboard side, there is a separate generating set to supply current to the trawl winch. This consists of a Mirrlees T.L.A.3 Diesel engine driving a 95 kW Laurence Scott generator directly, and, by V-belt, a 20 kW exciter generator, also supplied by Laurence Scott and Electromotors, Limited. When proceeding to and from the fishing grounds, current will be provided for general ship's use by one or other of the Russell-Newbery sets, driving Hugh J. Scott generators; but when fishing, this supply will be taken from the generator which is belt-driven from the trawl-winch set, 2·5 kW of its output being used to excite the trawl generator and the remaining 17·5 kW for the ship's services. The direct-driven generators can then be shut down, thus achieving a useful saving of fuel.

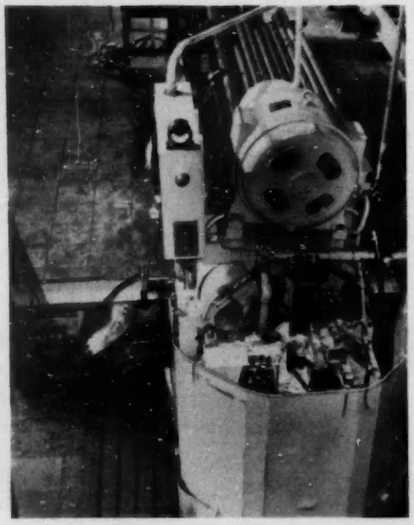
The trawl winch, supplied by James Robertson and Sons, Fleetwood, has a barrel capacity of 650 fathoms of 2¼ in. warp and is controlled through a modified Ward-Leonard system giving seven steps "heave" and four "veer." The winch motor, supplied by Laurence Scott and Electromotors, Limited, delivers 115 b.h.p. at 60 r.p.m.

The navigating equipment includes a Decca Navigator and also a Deccometer, placed in the wheelhouse, from which the helmsman can steer directly and follow the fish. There is a Decca radar set of the 212 type, giving six ranges from half a mile to 30 miles, with a discrimination of 25 yards on the shorter ranges. For communication there is a Pye "Hornet" 50 watt transmitter-receiver, giving crystal-controlled radiotelephone facilities on the medium-frequency band. The receiver section can also be tuned over the medium-frequency and high-frequency bands, and works in conjunction with a direction-finding loop. For communication from ship to ship and, in harbour, from ship to shore, there is a Pye PTC 724 two-channel V.H.F. transmitter-receiver, using the marine amplitude-modulated band, with an output of 15 watts. A Pye sound-reproducing equipment provides crew entertainment and can also be used for communication from the bridge to the engine room, the trawl winch, and the aft towing position.

The steering gear is of the Barton-Svendborg hand-hydraulic type, supplied by the Barton Engineering Company, Limited. The rigging was supplied and fitted by Industrial and Maritime Riggers, Limited. For life-saving purposes there is a wooden lifeboat, supplied by David Williams and Sons (Boats), Limited, Aberystwyth, which is handled by a Schat single-arm davit, and two rubber dinghies, one to hold six men and the other ten, which were supplied, with their containers and cradles, by R.F.D., Limited, Godalming.

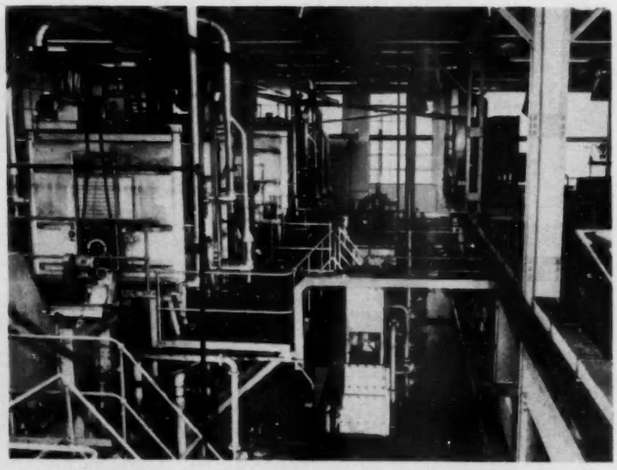
Production

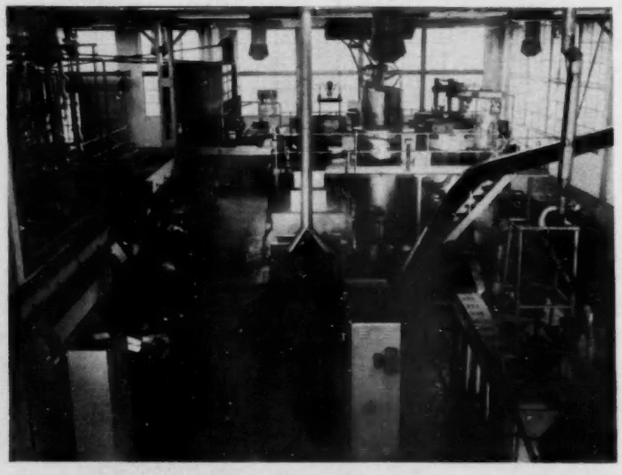
AUTOMATIC PRODUCTION OF TAPERED ROLLER BEARINGS



(Left) Numerous special-purpose machines are used. This single-spindle automatic is of British Timken's own design.

(Right) After machining, the cups and cones are hardened and tempered. Cones are dealt with automatically in this line of gas-fired furnaces.





BRITISH TIMKEN, LIMITED, Duston, Northampton, decided some five years ago to develop automatic production lines for their tapered roller bearings, and a new building was erected to house one cup and one cone line. The lines enabled the necessary operating and development experience to be obtained, and it was decided to put down two improved cup and two improved cone lines in place of the original equipment. The new lines are now in full operation. Obviously the ideal production line is one which operates continuously on a single bearing size, but practical limitations are imposed by the available market, and a compromise has been reached at Dunston by designing the production lines to deal with a small range of sizes between 1½ in. and 3 in. outside diameter. The tapered roller bearings are supplied principally to the motor car trade at home and overseas, and the new production lines have an average output at present of some three million bearings a year. This figure is not the designed optimum output, however, and as demand for new sizes of bearing becomes sufficient to make their tooling economic, they will be added to the production range of the automatic lines, until the desired maximum annual production rate of five million bearings is reached.

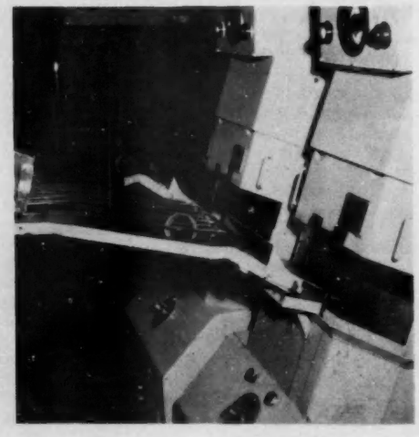
Further expansion of automatic manufacture will depend upon markets. In this connection the company foresee two developments which will assist such expansion. Firstly, they look for much greater standardisation of tapered roller bearing sizes in this country, which would then come more into line with the United States, where a large proportion of the motor car manufacturers use the same bearings in their front wheels. New designs of lightweight, high capacity tapered roller bearings are already offered by British Timken at a considerable price differential as compared with other sizes, the object being two-fold—to pass on to customers economies resulting from automatic manufacturing, and to stimulate standardisation, so making extensions to the automatic lines possible. Secondly, British Timken are ready and willing to accept the challenge of European free trade in which they can see a potential increase in market size favourable to the new manufacturing techniques.

SELF-CONTAINED WORKS

The automatic production lines, known as the "NB project," are housed in a completely new building (from which the initials "NB" are derived) adjacent to but separated from the main factory at Duston, and operated as a self-contained unit. There are three main departments, for automatic machining, heat treatment, and grinding and assembly respectively, the three together having a floor area of 33,000 sq. ft. A separate boiler house, compressor house and electrical substation provide the necessary heat, compressed air and power. Heating is by means of six thermostatically-controlled plenum batteries. The production personnel numbers 20 on permanent day shift and 100 working on a three-shift system. Of the total of 120, 10 are supervisors, 27 inspectors, 34 setters and 49 operators. Other personnel number 42, and include 28 mechanical and electrical maintenance men (75 per cent. of whom are fully skilled), 14 shop cleaners and storekeepers. As additional automatic equipment is installed the total number of personnel will be gradually reduced. Tooling exists at present for four sizes on the larger cup line and five on the smaller, and for three sizes of larger cones and four smaller. Inspection throughout is on a statistical quality-control basis, with patrol inspectors taking spot checks at the machines at regular intervals. Operators are responsible for intermediate spot checks, and for appropriate action, based on their own and the inspectors' findings. In addition there is 100 per cent. inspection at completion of

(Above) Cups are heat treated in bulk and quenched individually to prevent distortion. Pit-type furnaces are used.

(Right) Cup quenching is done in special machines, each heated component being held in a jig hydraulically before the quenching oil is flooded over it.

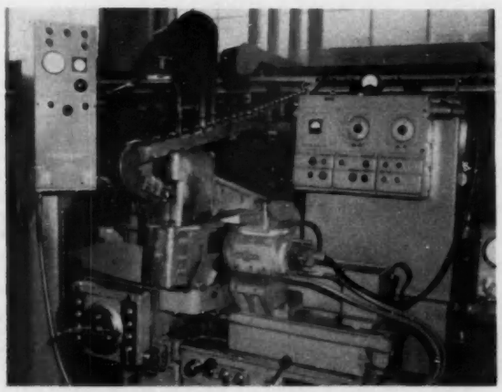


manufacture on certain visual and dimensional standards.

AUTOMATIC MACHINING

Production commences with the automatic machining of cups and cones from hot rolled alloy steel thick-walled tubes made specially for Timken by Tube Investments, Limited. This takes place on four lines in the automatic machine shop. Line 1 consists of three tungsten-carbide tooled single-spindle automatics, of British Timken design, producing cups from 2¼ in. to 3 in. outside diameter, a separate final chamfering machine, and a Schmidt peripheral marking machine. The Timken automatics discharge to bulk storage from which components are sorted mechanically for chamfering and marking. Line 2 is equipped with two tungsten-carbide tooled Wickman five-spindle automatics, producing cups from 1½ in. to 2¼ in. outside diameter. Final chamfering is done on the Wickman machines, and a single-deck spiral brush feeder passes the cups to a separate Schmidt marker. Line 3, which is for larger cones, is at present being equipped with tungsten-carbide tooled six-spindle Wickman automatics, which will also carry out final chamfering, leaving only the marking to be done on a 25 ton crank press. A single-deck brush feeder provides buffer storage between machining and marking. Small cones are produced in Line 4, which comprises three 1⅛ in. four-spindle Acme-Gridley automatics, a separate vertical chamfering machine and marking equipment similar to that in Line 3. A small bulk-storage hopper and sorting mechanisms are incorporated to feed the cones for chamfering and marking.

Grinding is automatic. The cup lines are shown here. Spiral brush feeders provide in-line storage. The cone lines are similar.



This Heald bore grinder in the larger cup line is typical of the grinding machines. The machine feed and the circulating conveyor supplying it are also visible.

Components from each line are elevated separately into large storage hoppers, which feed the heat-treatment department and have sufficient capacity to permit of complete automatic-shop tool changing without disrupting production in the following departments. Swarf from the multi-spindle machines is conveyed in ducts by pneumatically-operated forks, while that from the Timken automatics is cleared by high-pressure coolant jets in a separate duct. Both systems lead to a swarf house, where the swarf is crushed for disposal. Tools for the various operations are pre-set in blocks and held ready for replacement or change of production run.

TWO HEAT-TREATMENT INSTALLATIONS

Cups and cones are heat treated by carburising and quenching in oil, re-heating to 780 deg. C. and quenching in oil again, tempering at 165 deg. C. for two hours and air cooling. Carburising takes 7½ to 10 hours at 920 deg. C., and the case depth is 0·035 in. to 0·055 in. according to the size and section of the component. Certain of the larger, thin section cups require controlled jig quenching to prevent distortion, but this is not necessary for the range of cones. Two different installations are therefore provided in the heat-treatment section.

Machined cones are vibrated from bulk storage hoppers and elevated at controlled rates into a continuous rotary spiral carburising furnace. After quenching at the discharge end the cones are washed in a spiral washing machine and passed to the hardening furnace. Here they are heated and quenched again. Another washing follows before they enter the tempering furnace.

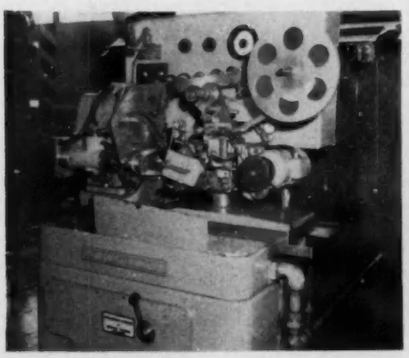
All three furnaces are town-gas fired, and automatically controlled. Separate sulphur-extraction and "RX" gas-generating plants treat the town gas, and propane is added before it is used as the carburising medium.

In the second heat-treatment section there are two electrically-heated pit-type carburising furnaces, fed from four bulk cup storage hoppers, a quench receptacle capable of circulating 2,400 gallons of oil per minute and a circular trichlorethylene vapour de-greaser; all this equipment is in a circle of 7 ft. radius. Nickel-chrome work-containers, lifted by a central crane, are used to move the components between the units. Cups are vibrated from the bulk storage into the containers, carburised, quenched, de-greased and emptied into a feed hopper for the next operation, hardening. This is done on fully-automatic plant consisting of an eight-lane electric furnace, discharging at pre-set intervals into two hydraulic jig quenching machines. A hopper-fed one-way turnover unit and eight-way distributor supply components to the furnace pusher mechanism, and a slow-moving conveyor receives jig-quenched cups and elevates them from the oil quench tank. Tempering follows, in an electric, conveyor-type furnace, and the cups then pass to a sorting and limited-quantity storage unit which feeds them for shot blasting. Modifications are taking place in this section at present to make the shot blasting fully automatic. A separate service plant, containing two 5,000 gallon oil-storage tanks, pumping sets and two thermostatically-controlled Heenan and Froude coolers supplies the oil to both heat-treatment sections.

GRINDING CUPS

After heat treatment the components are again separated into four distinct lines, ready for grinding. Bulk storage hoppers, similar to those between the automatic machining and heat-treatment sections, receive the cups and cones and supply them automatically to the finishing lines as required. Cups pass through a sequence of operations consisting of: face grinding on a Gardner machine; outside diameter grinding on No. 3 Cincinnati centreless grinders, there being one roughing and one finishing machine per line; bore grinding, with three Heald 180 centreless machines for small cups and three Heald 190 Centrimatics for large cups; bore honing, with abrasive tape on machines designed by British Timken; and washing, by distillate from high-pressure jets above and below a twin-lane mesh belt. At the end of the lines there is 100 per cent. visual inspection for finish, chamfer, marking defects, and surface cracks, the cups being fed at a controlled speed along specially-designed rails in front of the operator. The cups are then greased, by complete immersion on a moving belt. Size control is automatic at each stage, and automatic air gauging, one unit to each line, is to be installed in the near future; this will measure bore size, bore angle, width and outside diameter.

Handling of cups between the grinding operations is fully mechanised, by means of spiral



Another special-purpose machine is this tape honing machine, used here on larger cup bores.

Two automatic lines grind, finish, and grade rollers supplied by the main factory.

Final assembly of tapered roller bearings is by semi-automatic machine.

Continuing Production

brush feeders, which give sufficient storage to allow for tool changing; vertical chain elevators; one-way turn-over devices; and cup alternators, which can turn cups back to back for outside diameter grinding. Each cup line is served by circulating conveyors behind the bore grinders and honing machines. The grinding conveyor feeds components to the machine-feed chutes, and when all the chutes are full, surplus components circulate on the same section of conveyor to wait for a vacant feed position. Finished ground components are elevated to the next conveyor section where a similar process takes place. Both cup lines are attended by the same personnel.

GRINDING CONES

The cones are processed simultaneously with the cups, both cone lines being identical. The sequence of operations is: face grinding, on a Rowland dial-feed duplex machine; race grinding, with two No. 1 Cincinnati Microcentric machines in each line; bore grinding on three Heald 190 Centrimatic grinders; rib grinding on special machines of British Timken design; race tape honing, for which special machinery is now being built; jet washing; and 100 per cent. visual inspection. Automatic air gauging, similar to that being applied to the cup lines is soon to be installed. Handling of cones between operations is by equipment similar to that on the cup lines, and the two cone lines are also attended to by a single set of operators.

Rollers, in two sizes, are also processed in the grinding section, from cold headed, barrelled and hardened parts supplied by the main factory. There are two roller grinding lines and the rollers pass through seven operations. They are first given a rough body grinding, on a No. 2 Cincinnati centreless grinder with hopper feed. This removes stock from 0·008 in. to 0·010 in. on the diameter. A second body pass on an identical machine, with stock removal of 0·004 in. to 0·005 in. on diameter, is followed by spherical roll-end grinding and a finishing body pass, with 0·002 in. stock removal. The rollers are then washed and dried automatically, and subjected to visual inspection. Finally, they pass through automatic grading machines, which can segregate them into grades, each differing by less than 0·00025 in., or half grades of 0·000125 in. on body diameter as required.

At the end of the grinding lines is an assembly point where cups, cones, rollers, and cages drawn from the main factory are assembled in a semi-automatic operation. A final wash follows this operation, and the assembled races are then greased by total immersion and packed, either as complete bearings or as separate cups and assembled cones, according to customers' requirements. This packing is now done by hand, but is in the process of being mechanised.

SERVICES

Hydraulic power is supplied from a central pumping system incorporating a by-pass centrifuge. Four alternator sets, with two more in reserve, provide high-frequency current for the wheel heads on the bore grinders. Service mains, for grinding-coolant supply and return, compressed air, hydraulic supply and return, normal and high-frequency electric current are encased in the circulating conveyors. One main service trench links all four production lines and continues into a separate service block, where grinding coolant is cleaned magnetically.

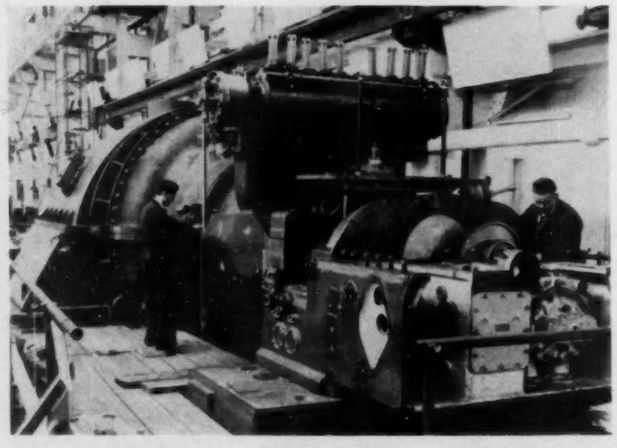
B.T.H. BUILD TURBINES IN IRELAND

The British Thomson-Houston Company, Limited, introduced planned decentralisation of their manufacturing activities as far back as 1912, and they now have several large factories in various parts of the country. The latest addition to their extensive production facilities is the new turbine and turbo-generator factory at Larne, Co. Antrim, Northern Ireland, which was officially opened by H.R.H. The Duke of Gloucester, on October 24.

The decision to establish the new factory was taken in 1949, when it became obvious that the turbine department at Rugby, although modernised and re-equipped, could not meet the demand for B.T.H. turbo equipment. Larne was chosen partly because the availability of labour—the works will employ more than 3,000 when they are in full production. Another deciding factor was the offer of full co-operation and great practical assistance by the Northern Ireland Government.

Site clearance began in January, 1954, and a little over 12 months later the first section of the project, a 70,000 sq. ft. blading factory, was in production. The main turbine factory was completed in November, 1956, some 16 weeks before the contract date, and manufacturing started immediately. By September, 1957, the first turbine, a 30,000 kW machine for Chamoun Power Station, Beirut, was under test, and other turbines, of 60,000 and 120,000 kW were in production.

Larne works are self-contained, with commercial and design departments, drawing offices and auxiliary services, including a toolroom, press shop and plating section. Canteen and welfare facilities are provided on an appropriate scale. Separate buildings house a gas-producing plant, the works power station, and a transport section, which is responsible for road vehicles and for the electric materials-handling vehicles used in the works. The main production units are the blade factory, already mentioned, and the turbine factory, a single building covering 370,000 sq. ft. and specifically designed and equipped for the manufacture of steam turbines and their associated alternators from 15,000 kW up to the largest sizes yet foreseen.

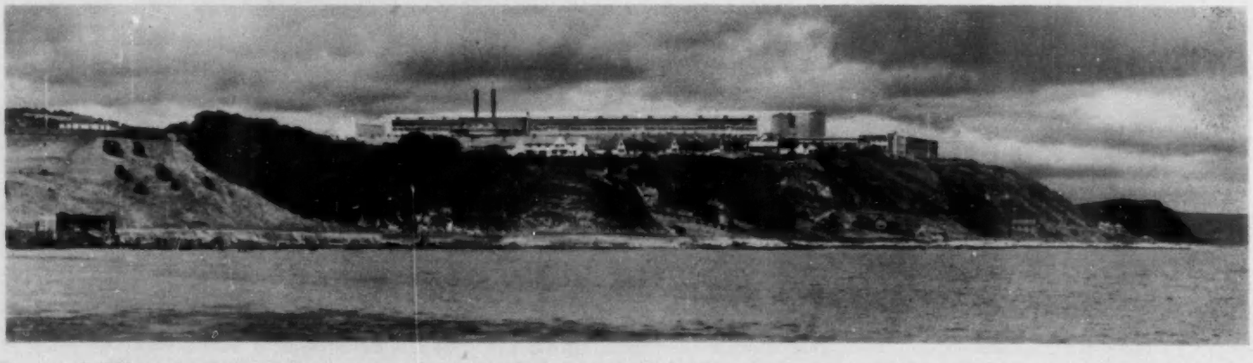


This 30,000 kW turbo-alternator for Beirut, the first machine to be completed in B.T.H.'s new works, is typical of the products of Larne.

CONTINUITY OF FLOW

An impressive set of machine tools has been provided to carry out the precision work necessary on steam turbines, and many of the machines are equipped with hydraulic or electronic profile-copying mechanisms; much of the electronic gear is of B.T.H. design and manufacture. In the production of heavy capital equipment continuity of flow is very difficult to obtain, but by careful planning it has been achieved at Larne. The 100 ft. wide heavy machining and erecting bays are provided with overhead cranes at two levels; one of these cranes, for handling complete wound stators, is of 200 tonscap acity. Heavy, special-purpose machine tools, selected on the basis of the Company's wide experience in the development of such plant at their other works, enable successive machining operations to be carried out with a minimum of handling, an important point when the size of some of the workpieces is considered.

Among the large machine tools may be men-



The new B.T.H. works at Larne, in Northern Ireland, are specially designed for the manufacture of turbines, up to the largest sizes yet envisaged.

tioned a vertical boring machine specially designed for work on large alternator stator frames up to a height of 25 ft., a 12 ft. by 32 ft. Kendall and Gent plano-mill, a 70 in. Craven lathe, a 35 ft. Noble and Lund horizontal boring machine, two 10 in. Asquith horizontal milling and boring machines with rotary tables, a 26 ft. by 60 in. Churchill shaft grinder, and 18 ft. and 16 ft. Craven vertical boring mills. Other large equipment includes two Hancock flame-cutting machines with electronic controls and a 70 ton annealing furnace.

Test facilities at Larne are extensive, in accordance with normal B.T.H. practice. They include the latest equipment for examination of welds and castings, newly developed apparatus for checking and blade vibration, and light-running test arrangements for turbines of all sizes. Air and hydrogen-cooled alternators of all sizes can be motor driven at zero power factor for testing. In addition, there is an overspeed pit, now under construction, for testing alternator rotors.

The labour intake is not restricted to personnel having previous experience in engineering, and in this connection the assistance of the Northern Ireland Government has proved invaluable. Vocational training centres were set up by the Government to give men short courses before they entered the company's employment, and the scheme has proved highly successful. As at other B.T.H. works a comprehensive training programme is in operation, and different types of apprenticeship are available, together with courses for university graduates.

The products of Larne works may be for any part of the world, and the existence of good facilities for transport of heavy single loads was another reason for the choice of location. Larne Harbour is only two miles away, and an extension and two new quays built on reclaimed tidal land have been constructed there. One-piece loads up to 45 tons can now be carried on the Larne-Preston vehicular ferry, and direct road access for loads up to this limit is thus possible to any part of the United Kingdom. For heavier single loads, new equipment will soon be ready for use at Belfast Harbour, where a 650 ft. quay is now being constructed. This quay will have a 200 ton crane and several smaller ones. Transport between Larne works and Belfast Harbour, a distance of 22 miles, will be by road, which has been widened and straightened to take a 200 ton transporter purchased by the Ulster Transport Authority.

Construction

NO HIGHWAY: THE BAR TO PROSPERITY

The further and more awkward a man's journey to work, the more liable he will be to absenteeism. This is a reasonable statement. Nevertheless, there had been no hard supporting evidence for the belief until the symposium on the " Highway Needs of Great Britain " held last week at the Institution of Civil Engineers here in London. Altogether, ten papers were presented ranging over the whole subject of the road needs of the country: what was wanted, and where, how much such roads would cost and how much was lost by not having them, the capacity of the civil engineering industry to build the roads and the priorities to be adopted in tackling the work.

All these and many other points were referred to in the papers and the ensuing discussion.* On the other hand, scant consideration was given to the materials and techniques of construction; and very properly so, for there is now no serious criticism that the necessary technical knowledge is lacking. About 750 delegates attended and they, at least, must be clearer about our motorway requirements. They may not, however, be quite so clear about what can be done within the badly congested urban areas —apart from the " ideal " solution of flattening the lot and starting again.

The roads problem is of a threefold nature: money, the administration machine and public opinion. To some extent sufficient of the first could overcome the lack of support from the other two, but generally speaking it is appreciated that the country's purse is not bottomless and that there are other calls on Government funds. At the symposium the delegates showed pretty clearly that they knew—anyway as individuals—how and where the Government's proposed £70 million a year grant for new roads could be well spent.

PUBLIC OPINION

As representatives of public opinion, however, the delegates were hardly typical. Speakers were addressing the converted: men who recognised the need for a good roads system and wanted only to know how to get it; men who, incidentally, have given this country the best-surfaced roads in the world. But public opinion as a whole does not appreciate the shortcomings of our trunk-road system. Even to-day, the faulty opinion is often expressed that the higher speeds on motorways will cause more accidents. This gloomy prophecy was countered by Mr. James Drake, county surveyor and bridgemaster of Lancashire, when he presented his own paper (on the relative priorities to be adopted in respect of constructing new roads and improving existing thoroughfares). If, said Mr. Drake, a motorway were to replace the Liverpool-East Lancashire road (the A580), personal accidents over a three-year period would be reduced from the present level of 222 to under 42. And the same opinion of the enhanced safety of motorways—due to restricted access for pedestrians and cyclists as well as the few road junctions permitted—could be deduced from the paper by Dr. W. H. Glanville and Dr. R. J. Smeed, respectively director and deputy-director (traffic and safety) of the Road Research Laboratory at Harmondsworth.

The plain fact is that the British public still prefers the twisting lanes and byways of the countryside and is haunted by the horrible thought that modern highways will claim many acres of heavily cropped agricultural land, and that such roads would scar and spoil the landscape. All this is just as, 100 years ago, people were led to resist the coming of the railways or, a mere 25 years ago, to abhor the possibility of hydro-electric dams in the glens of Scotland. Fortunately, however, public opinion seems to be changing. The publicity organised by the British Road Federation and the motoring organisations seems to be telling. It is becoming generally known that some 80 per cent. of Britain's traffic goes by road—and only one-fifth by rail. Greater use of private cars by the travelling public, and more extensive holidaying abroad with cars, are beginning to generate the favourable opinion of motorways that will force the administrative machine to turn over.

CO-OPERATION REQUIRED

And how weak is this administrative machine? At the symposium one county surveyor—one with a major road programme in hand—said that he could " only guess " at the Ministry of Transport's overall programme for trunk roads. Yet there are not many more than 50 county surveyors. Surely it should be possible to communicate the principles of the Ministry's plan among at least that small number of men? The plan seems sound enough and received the approbation of the delegates. Maps on view in an exhibition at the Institution during the symposium, and included among the illustrations to one of the papers, showed how well the proposed motorways served the centres of population. It would seem but a simple deduction to presume that they would also most nearly meet our highway needs.

The difficulties of getting a county road programme started were also mentioned by the same county surveyor. He gave it as his opinion that his plans had been put into effect only because he had been able to " hang on to his job " for long enough: time to study the local road needs, time to make the plans, and some more to get them accepted and started. It is a poor state of affairs if the counties are only going to get the roads if their surveyors are appointed young and remain for the rest of their careers.

The fact is that Britain's roads are probably the most congested in the world—20·79 vehicles per road-mile as compared to 16·85 in the United States. Considerable relief can be obtained by building new roads but this in itself is no solution of the urban problem. As Mr. Rowland Nicholas, city surveyor of Manchester, said: " The real problem from the point of view of the urban area is the elimination of the long-term parker from the business and shopping areas." Full access to the centres of activities will still be a vital problem even when the new motorways are built. Blackspots and bottlenecks have got to be eliminated one by one. This requires a comprehensive treatment of our transport problem—which should be treated as a single national problem.

ONE SOLUTION

Just prior to the symposium Brigadier T. I. Lloyd published in booklet form* his proposal for scrapping the railways as they are now known and replacing the permanent way by trunk roads. When he first put the idea forward in a paper to the Civils some three years ago he met some pretty caustic criticism from the railway people, but in this booklet much of that criticism is answered. The basis for the brigadier's suggestion is that the permanent way—with the rails and sleepers away—offers a first-class, well-consolidated sub-grade on which to lay trunk roads that would lead right into the heart of all the cities, towns, docks and works of the country.

The roads so obtained would have many of the characteristics of motorways: long stretches with only restricted access, small gradients and banked curves. High vehicle speeds—without harder driving—would be easy. Two questions immediately arise. First, would the 10,350 miles of double-way permanent way—normally levelled over a width of only 26 ft. to 30 ft. and forming the bulk of the railway system—be sufficiently wide to convert into adequate roads. Secondly, would the road vehicles that could be used on these roads carry all the freight and passengers that the railways do. Brigadier Lloyd answers both these questions with figures that produce a most formidable and attractive case.

Yet there is one problem unanswered in this booklet. No claim is made that the converted railways would make perfect roads—only that they would provide a very much better system than is otherwise possible—but what of the intermediate state during the change-over. The civil engineering industry is well equipped with plant to lay the roads at high speed, but the disruption meanwhile might be catastrophic. True, a start could be made with the buttercup and daisy lines, but then we get back to public opinion and that is a very hard nut to crack. On the other hand beginning with the main line from Kings Cross to York might be less unpopular but it would be an awful headache for the executive machine.

No, the transport problem is with us in a very big way. Far bigger than in Belgium, France or the United States where it is so often suggested that they are getting over the difficulties more quickly than here. We can learn from overseas but some very hard study is also required here at home.

* The papers and discussion will be published by the Institution in book form, price £2, about next April.

* *Twilight of the Railways* by Brigadier T. I. Lloyd, C.B.E., D.S.O., M.C., Published by Forster Groom and Company, Limited, 23 Craven-street, W.C.2. (5*s*).

Atomic Review

Enigma Variations

LANGUAGE and other barriers make Soviet intentions a mystery and their elucidation a popular pastime. A visit to that country may add to rather than resolve the enigma. Thus the various published statements on the Soviet nuclear power programme have yet to be fully reconciled, and there appear to be discrepancies even in the available descriptions of reactors already under construction. Possibly the recent decision to replace the present five-year plan (owing to the discovery of " new large deposits of various raw materials and sources of power ") with another of seven years duration means that plans are still in a state of flux. Nevertheless, work is certainly in progress, and the foundations for the first full-scale Soviet nuclear power station are reported to be in position near Leningrad. The following notes are based largely on information collected during a recent visit to the Soviet Union by a member of the staff of ENGINEERING, who inspected both the Academy of Sciences' first experimental nuclear power station and the Joint Nuclear Research Establishment at Dubna.

Power Reactor Projects

In Atomic Review last August 30 details of the Soviet reactor construction programme were published, as given in a recent United Nations report. In one section of the report it was stated that the capacity of stations would be of the order of 200 MW, while a table appeared to give a conflicting view. Two initial projects were named: one embraced two power stations of 420 MW gross electrical capacity using pressurised-water reactors; while the other involved only one 400 MW station of graphite-moderated water-cooled design. It is of course possible that the first statement referred to electrical output from one reactor, since all stations are likely to have two, but certain other differences remain obscure.

Pressurised-Water Designs

At the last sectional meeting of the World Power Conference, held in Belgrade, Dr. S. Skortsov gave details of a Soviet 420 MW station employing two pressurised light-water cooled and moderated reactors. These details were published in Atomic Review last June 21. A more extensive description provided by the Soviet authorities included the part section of a reactor vessel shown in Fig. 1, which appeared in the October issue of *Nuclear Engineering*, and has been reproduced by courtesy of that journal. It will be seen that the vessel has a flat top. On the other hand, in the atomic energy pavilion of the permanent industrial exhibition in Moscow, a model of a pressurised-water reactor power station is shown, in which the reactor vessel has two domed ends. The model, which appears in Fig. 2, is described as representing a projected 200 MW power station. A flat-topped vessel would seem to have advantages in the arrangement of control rods and for charging and discharging fuel elements; but since the flat cover would have to be considerably thicker to contain the same pressure as a domed end, problems of thermal stress would probably be severe.

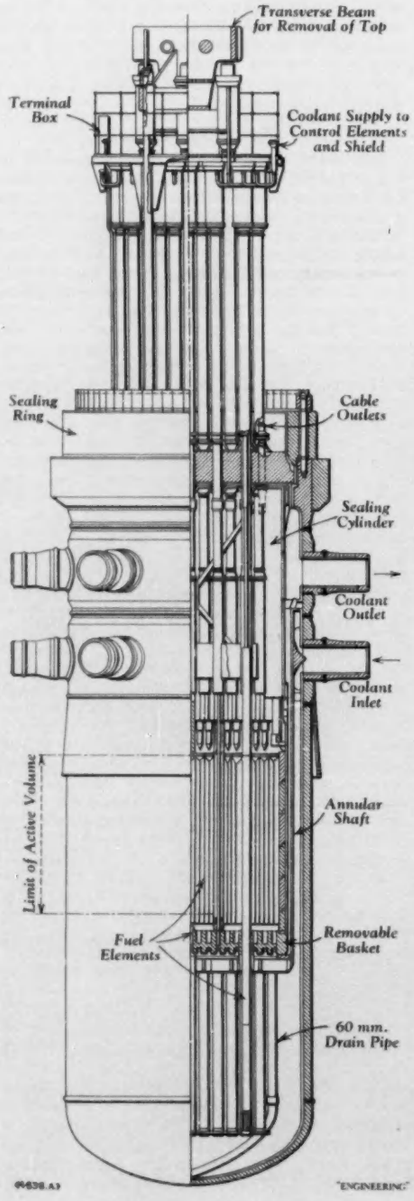


Fig. 1 (left) Part section of a reactor pressure vessel for a projected Soviet 420 MW nuclear power station. The station is to have two pressurised light-water cooled and moderated reactors. The flat top to the reactor vessel is of special interest.

A sketch of the 200 MW (electrical) reactor is illustrated in Fig. 3, and Fig. 4 is a circuit diagram. It will be seen that coolant flows into the reactor through the upper part. In Fig. 1, the inlet and outlet ports are shown in the reverse positions. The reactor coolant pressure is given as 100 atmospheres, which corresponds to the Belgrade and United Nations reports, though the reactor outlet temperature is stated to be 270 deg. C. as against 275 deg. C. in the other two cases. The steam pressure in the secondary circuit at the heat-exchanger outlet is said to be 32 atmospheres and 30 atmospheres at the turbine, which agrees with the Belgrade and U.N. figures, while the steam temperature is 235 deg. C.

The installation described at the Moscow exhibition is stated to consist of a single unit comprising a reactor and four separate power circuits, each including a heat exchanger and turbo-generator set. In the Belgrade report there are said to be six circuits (each including primary and secondary systems) per reactor, but since the turbo-generator sets are rated at 70 MW and there are two reactors, two circuits must supply each turbine. (In this respect the model at the exhibition appears to correspond less with the associated description, which mentions four circuits per reactor, than with the Belgrade and U.N. accounts, since, as can be seen from Fig. 2, there appear to be six pairs of connections, if these are disposed symmetrically about the reactor.)

Certain of the reactor fuel elements are of natural uranium while others are enriched. Compensation for lost reactivity and reactor control are effected by movement of enriched elements. Close control is by means of neutron absorbing rods.

Resolving Differences

The principal differences that emerge lie in the design of the reactor vessel, the number of coolant and steam circuits per reactor, and the power output of the station. The last point may be explained by an ambiguity in the word station. The 420 MW station may in some statements be regarded as two independent stations each with a single reactor and associated turbines. Indeed these may be the two stations referred to as project 1 in the U.N. report. Alternatively, the two PWR stations of project 1 may be of different design, one having a reactor vessel with a flat top. Another possibility is that the reactor model shown at the exhibition has now been superseded, though if construction is already in progress, the designs must have been completed before the exhibition description was prepared. The 420 MW station is due for completion by 1960. The other major stations are hardly likely to be completed earlier, and the most optimistic total for all the stations mentioned in the U.N. report is 1,500 MW. If the figure given by Mr. Khrushchev at the 20th Congress of the Soviet Communist Party of 2,500 MW by 1960 is correct, then another parallel programme must exist. Alternatively recent planning changes may mean that Mr. Khrushchev's figure has been abandoned.

Fig. 2 Model of a projected Soviet 200 MW nuclear power station. The vessel for the pressurised-water reactor has domed ends. On the right can be seen a container for spent fuel elements.

It is possible that there are in fact two independent programmes: the one described in the U.N. report, which was planned by the Ministry of Power Stations (though there has now been a general decentralisation of ministerial responsibility); and a separate programme organised by the Academy of Sciences. It is of interest that a thriving town has sprung up near the Academy of Sciences' 5 MW station, though the existence of other small experimental reactors on the site cannot be confirmed. The new " scientists' city " being built near Novosibirsk in Siberia and recent statements concerning the dispersal of scientists towards the east may mean that the centre of gravity of technical research in the

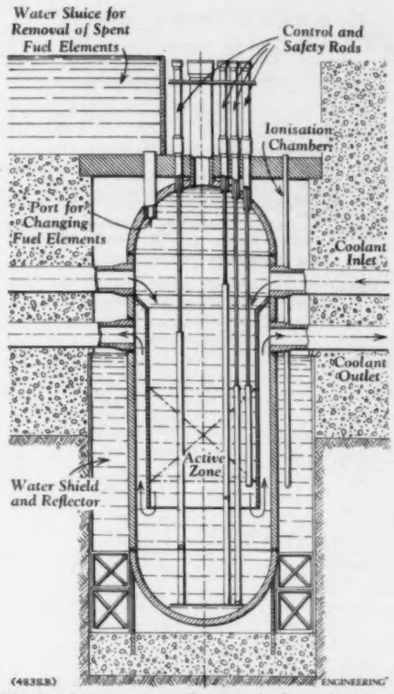


Fig. 3 Arrangement of pressurised-water reactor for projected Soviet 200 MW nuclear power station. There are four coolant and steam circuits per reactor each with associated heat exchanger and turbo-generator set. One circuit is shown below.

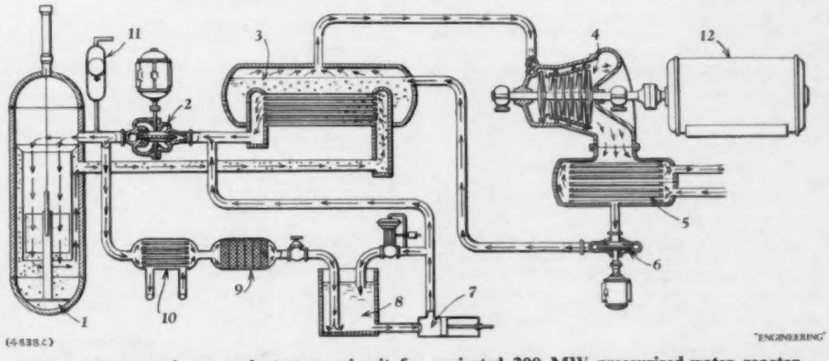


Fig. 4 Layout of one coolant-steam circuit for projected 200 MW pressurised-water reactor.

1. Reactor. 2. Circulating pump. 3. Steam generator or heat exchanger. 4. Turbine. 5. Condenser. 6. Feed pump. 7. Return pump for decontaminated reactor coolant. 8. Reservoir for decontaminated coolant. 9. Filter. 10. Cold trap. 11. High-pressure compensating device. 12. Generator.

Soviet Union is moving eastward. This may be a prelude to closer industrial integration with China, desirable in view of the current Soviet shortage of labour. However, in the case of nuclear power such a move would conflict with the statement in the U.N. report that the Soviet Union's greatest need for nuclear power is in European Russia, since elsewhere hydro-electric and coal resources are substantial.

Power Prospect

The United Nations account mentions six Soviet projects (pressurised-water cooled and moderated reactor; pressurised-water-cooled graphite-moderated reactor; boiling-water reactor; sodium-cooled graphite-moderated reactor; aqueous homogeneous reactor using the thorium-uranium 233 cycle; and a fast reactor operating on the uranium-plutonium cycle. It is significant that all these reactors require enriched uranium fuel. This may mean that stocks of enriched uranium are considerable and that by the time they are consumed a new and more economic source of power is expected to be available; that a cheap method of separating the uranium isotopes has been discovered; or that there is wide confidence in the prospect of using plutonium as enrichment.¶

Joint Nuclear Research Institute

Details of the new 10 GeV proton synchrotron operated by the Joint Nuclear Research Institute were given in Atomic Review on June 22, 1956, and May 3, 1957. The Institute, which is situated at Dubna on the Volga, is an international body corresponding to the European Organisation for Nuclear Research (CERN). The signatories to the agreement establishing the Institute are Albania, Bulgaria, Hungary, the German Democratic Republic, China, Northern Korea, the Mongolian Republic, Poland, Roumania, the U.S.S.R., and Czechoslovakia. The Institute's postal address is Moscow, Main Post Office, Box No. 79.

Organisation and Invitation

The director of the Institute is Academician D. I. Blokhintsev, who is well known for his work on the first Soviet nuclear power station and his paper on the subject at the first International Conference on the Peaceful Uses of Atomic Energy at Geneva. His two deputies are the Czech Professor Vaclav Votruba and the Polish Professor Marian Danysz. There is also an administrative director. The principal director is elected for three years and the vice-directors for two. Thus Professor Votruba is likely to return to his home university after his period of office. Professor Votruba stated during an interview that the Institute would welcome the addition of two western physicists to its staff, who would complete a tour of duty at Dubna before being succeeded by two others.

Four Laboratories

The Institute embraces four laboratories: a laboratory of nuclear problems, a laboratory of high energies, a laboratory of neutron physics, and a laboratory of theoretical physics. At present the work is mainly grouped round the two accelerators: the 10 GeV proton synchrotron, which, until recently at least, has been undergoing trials, and a 680 MeV synchro-cyclotron completed in 1949. The 10 GeV machine is under the direction of Professor V. I. Veksler, and Professor V. P. Dzelepov manages the 680 MeV cyclotron.

New Projects

Professor Votruba stated that the Institute was to have a pulsing reactor. A pulsing reactor is one which can be made supercritical for a brief period in order to produce intense intermittent beams of neutrons, and in the simplest form might comprise a toroid of fissile material through which a plug of fissile material falls. The American reactor Godiva, which disintegrated during a power surge, was designed to give high-intensity neutron pulses. The project is to be in the charge of Dr. G. M. Frank. A projected 50 GeV accelerator, which is to be built at Dubna, will employ the principle of strong focusing and be 500 metres in diameter. Certain reports published by the Institute will be discussed in a subsequent Atomic Review.

General Notes

Winfrith Site

Work on the construction of the United Kingdom Atomic Energy Authority research establishment on Winfrith Heath was due to begin on November 25. The station will be similar in some respects to Harwell and it is known that several prototype reactors are to be built there. As stated in Atomic Review last August 30, the General Electric Company have been awarded a contract for construction of a zero-energy version of a high-temperature gas-cooled reactor there. The reactor is expected to have ceramic fuel elements and to use thorium-uranium 233 breeding cycle.

Neptune Critical

Neptune, a zero-energy reactor built at the Atomic Energy Research Establishment, Harwell, is now in operation. It went critical for the first time on November 7, 1957. Neptune will be used to study the detailed behaviour of neutrons in water-moderated core designs, with specific reference to a pressurised-water reactor for submarine propulsion. The reactor will be used to check the design calculations for the land-based prototype submarine reactor, on which work has begun at Dounreay. Neptune will be operated by an Admiralty team at Harwell in association with Authority staff.

Neptune uses enriched uranium as the fuel and ordinary water as the moderator; no special cooling is required since only a few watts of heat will be generated. The reactor has been designed to allow the rapid assembly of many different kinds of cores. The core of the reactor is formed by assembling boxes of fuel element plates inside a large heavily shielded aluminium tank which contains the water moderator. The level of the water in the tank can be adjusted precisely to any required level and is used as one means of regulating the reactor. An additional method of control is by a neutron-absorbing cadmium rod, moving vertically in or out of the reactor core. The reactor is shut off by allowing two groups of neutron-absorbing plates to fall by gravity into the core, and by dumping the water at the same time into storage tanks situated beneath the reactor. The reactor is not pressurised since the heat output is small and boiling cannot occur even at atmospheric pressure, but the water can be heated to about 90 deg. C. to study the variations in neutron behaviour caused by increased moderator and fuel temperatures.

Rolls-Royce Limited, as a member of Vickers Nuclear Engineering Limited, were responsible to the Admiralty for the design and construction of Neptune. The Atomic Energy Research Establishment was responsible for providing detailed advice, particularly on physics, instrumentation and safety, during the design and construction stages, and also for supplying the reactor building, essential services, and fuel. The principal sub-contractors in the design and construction of the reactor itself were Elliott Brothers (London) Limited and Head Wrightson (Teesdale) Limited.

Exhibition for Geneva Conference

Concurrently with the Second Conference on the Peaceful Uses of Atomic Energy, sponsored by the United Nations Organisation and to be held in Geneva from September 1 to 14, 1958, there will be staged a commercially-organised international exhibition in the Palais des Expositions, Geneva. N.E.T.A.C. (Nuclear Energy Trade Associations' Conference) has undertaken the responsibility of co-ordinating the applications for space from United Kingdom participants so that an impressive British section of the exhibition may be staged. Information about the exhibition may be obtained from N.E.T.A.C. at 32 Victoria-street, London, S.W.1.

NOTICES OF MEETINGS

Birmingham Exchange and Engineering Centre

BIRMINGHAM
"Guided Missiles," by W. R. Thomas. Fri., Nov. 29, 6.30 p.m. (Tickets required.)

British Institution of Radio Engineers

LONDON
Annual General Meeting, for members only, at 6 p.m. "Transmission Standards and Signal Distortion in Television and Other Communication Systems," by Dr. Ir. A. van Weel, at 7.15 p.m. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Nov. 27.
CHELTENHAM
"Automatic Programming," by Dr. P. M. Woodward. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri. Nov. 29, 7 p.m.

Building Centre

LONDON
Film "How Dry Rot Grows," exhibited by Protim Ltd. Wed., Nov. 27, 12.45 p.m.

Chemical Society

BIRMINGHAM
"Electron Interactions," by Dr. J. W. Linnett. Birmingham Branch. Chemistry Department, The University, Birmingham. Fri., Nov. 29, 4.30 p.m.
BRISTOL
"Uses of Models in Chemistry," by Professor D. H. Everett. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Nov. 28, 5.15 p.m.
SOUTHAMPTON
"Hydrocarbon Compounds of Transition Metals," by Professor G. Wilkinson. Southampton Branch. Chemistry Department, The University, Southampton. Fri., Nov. 29, 5 p.m.

Engineering Metrology Association

LONDON
"Work of the Metrology Mechanisms and Noise Control Division, Mechanical Engineering Research Laboratory, Glasgow," by Dr. C. Timms. Thurs., Nov. 28, 7 p.m.* (Tickets required.)

Illuminating Engineering Society

LONDON
"Planning the Interior: the Expression of Current Ideas and Requirements," by Brian P. Westwood. Royal Institute of British Architects, Portland-place, W.1. Wed., Nov. 27, 6 p.m.
HULL
"Exterior Lighting at a Modern Airport," by J. Morse. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Tues., Nov. 26, 6.30 p.m.*
LEICESTER
"Road Vehicle Lighting," by G. E. Charlesworth. Leeds Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., Nov. 25, 7 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Functional and Decorative Lighting in the Home," by Arthur Holden. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Nov. 29, 7.30 p.m.
CARDIFF
"The Cement Gun in Use," by W. J. Young. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Nov. 26, 7.15 p.m.
LEEDS
"Nuclear Reactors for Power Production," by J. A. Dixon. West and East Yorkshire Branch. The University, Leeds. Mon., Nov. 25, 7.30 p.m.
SHEFFIELD
"Factory Insulation: Its Place in the National Economy," by R. G. Hayes. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Nov. 28, 7.30 p.m.

Institute of Fuel

LONDON
Conference on "Pulverised Fuel." Institution of Civil Engineers, Great George-street, S.W.1. Wed. and Thurs., Nov. 27 and 28, 10 a.m.
BIRMINGHAM
"Refractories for the Industrial Boiler and Furnace," by N. W. Hinchcliffe. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Nov. 28, 6.30 p.m.
NOTTINGHAM
"A Review of 25 Years' Development in Steam Power Plant for Electricity Generation," by O. S. Woods. East Midland Section. Gas Showrooms, Nottingham. Thurs., Nov. 28, 6.15 p.m.

Institute of Marine Engineers

LONDON
"Nuclear Propulsion of Ships," by Sir Christopher Hinton and R. V. Moore. Joint Nuclear Marine Propulsion Panel. Wed., Nov. 27, 5.30 p.m.*

Institute of Packaging

LIVERPOOL
"Packaging of Frozen Foods," by M. J. Smedley. Merseyside Branch. Bradford Hotel, Tithebarn-street, Liverpool. Tues., Nov. 26, 6.30 p.m.

Institute of Physics

LONDON
Symposium on "The Design of Physics Research Laboratories." London and Home Counties Branch. Royal Institution, Albemarle-street, W.1. Wed., Nov. 27, 2.30 p.m. (Tickets required.)

Institution of Chemical Engineers and Physical Society (Low Temperature Group)

LONDON
Joint Symposium on "Recent Developments in Industrial Low-Temperature Gas Separation." Royal Institution, Albemarle-street, W.1. Tues., Nov. 26, 10 a.m. and 2.30 p.m.

Institution of Civil Engineers

LONDON
"Design and Construction of a Dry Dock at South Shields for Brigham and Cowan Ltd.," by P. F. Stott and L. M. Ramage. Tues., Nov. 26, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Problems of Sound and Television Broadcasting Coverage," by G. Millington. Radio and Telecommunication Section. Mon., Nov. 25, 5.30 p.m.*
"The Digital Computer Applied to the Design of Large Power Transformers," by W. A. Sharpley and J. V. Oldfield. Thurs., Nov. 28, 5.30 p.m.*
BIRMINGHAM
"Magnetic Materials," by Professor F. Brailsford. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Nov. 25, 6 p.m.*
CHESTER
"Earthing of Low- and Medium-Voltage Distribution Systems and Equipment," by F. Mather. Mersey and North Wales Centre. Town Hall, Chester. Mon., Nov. 25, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Electrical Equipment for Rectifier Locomotives," by H. B. Calverley, E. A. K. Jarvis and E. Williams. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Nov. 25, 6.15 p.m.
Faraday Lecture on "The Electrification of the British Railways," by G. H. Fletcher. North Eastern Centre. City Hall, Newcastle-upon-Tyne. Tues., Nov. 26, 7 p.m.
PORTSMOUTH
"Measurement of Earth-Loop Resistance," by Dr. G. F. Tagg. Southern Centre. City Council Chambers, Portsmouth. Wed., Nov. 27, 6.30 p.m.
WEYMOUTH
"Equivalent Circuits of Transistors and Their Application," by L. E. Jannson. Southern Centre. South Dorset Technical College, Weymouth. Fri., Nov. 29, 6.30 p.m.

Institution of Electronics

LONDON
"High Fidelity Reproduction of Sound," by C. Brown. Institute of Education, University of London, Malet-street, W.C.1. Thurs., Nov. 28, 6.30 p.m.

Institution of Engineering Designers

LONDON
"Electrical Breakdown of Dis-similar Metals," by Dr. G. Butler. Thurs., Nov. 28, 6.45 p.m.

Institution of Heating and Ventilating Engineers

EDINBURGH
"Current Practice in School Heating," by H. Oliver. Scottish Branch. 25 Charlotte-square, Edinburgh. Tues., Nov. 26, 7 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Fretting Fatigue." Applied Mechanics Group. Wed., Nov. 27, 6.45 p.m.*
"Recent Developments in the Manufacture of Castings," by J. L. Rice, R. W. Ruddle and P. A. Russell. Industrial Administration and Engineering Production Group. Fri., Nov. 29, 6 p.m.*
"Some Aspects of Hinkley Point Project," by R. E. Zoller. London Graduates' Section. Thurs., Nov. 28, 6.30 p.m.*
BIRMINGHAM
"Transmission Developments for Public Service and Heavy Goods Vehicles," by A. Gordon Wilson. Birmingham A.D. Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Nov. 26, 6.30 p.m.
LINCOLN
"Principles and Applications of Spark Machining," by D. W. Rudorff. East Midlands Branch. Technical College, Lincoln. Wed., Nov. 27, 7.15 p.m.
LUTON
"Principles and Applications of Spark Machining," by D. W. Rudorff. Eastern Branch. Town Hall, Luton. Tues., Nov. 26, 7.30 p.m.
SHEFFIELD
"Problems and Trends in Pressure Vessel Design," by Professor J. P. Duncan. Yorkshire Branch. The University, St. George's-square, Sheffield. Wed., Nov. 27, 6.30 p.m.

Institution of Production Engineers

LINCOLN
"Management and Its Application to Maintenance Work," by R. W. H. Maling. Lincoln Section. Ruston Club, Lincoln. Thurs., Nov. 28, 7.30 p.m.
MANCHESTER
"Machine Tool Development in the U.S.S.R.," by Norman Stubbs and Peter Trippe. Manchester Section. Manchester College of Science and Technology, Sackville-street, Manchester. Mon., Nov. 25, 7.15 p.m.
SHREWSBURY
"From Diamond to Spark Machining," by G. Fefer. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., Nov. 27, 7.30 p.m.
WORCESTER
"Mechanical Handling," by O. J. B. Orwin. Worcester Section. Cadena Café, Worcester. Wed., Nov. 27, 7.30 p.m.

Institution of Structural Engineers

LONDON
"The Relationship of the Architect and the Engineer," by L. A. Chackett. Thurs., Nov. 28, 6 p.m.*

Institution of Works Managers

GLASGOW
"The Art of Delegation," by J. C. W. Stead. Glasgow Branch. St. Enoch Hotel, Glasgow. Thurs., Nov. 28, 7.30 p.m.

Junior Institution of Engineers

LONDON
Annual General Meeting. Fri., Nov. 29, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Production of Motor Cycles," by P. Walker. Engineers' Club, Albert-square, Manchester. Fri., Nov. 29, 6.45 p.m.

Non-Destructive Testing Society

LONDON
"Modern Trends in Non-Destructive Testing," by R. S. Sharpe. 32 Welbeck-street, W.1. Fri., Nov. 29, 7 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
Annual General Meeting. "Service Performance Trials Carried out in the North Atlantic on the s.s. Cairndhu," by Dr. S. L. Smith and R. E. Clements. Mining Institute, Newcastle-upon-Tyne. Fri., Nov. 29, 6.15 p.m.*

Plastics Institute

MANCHESTER
"Machining and Finishing of Plastics," by B. E. Terry. North Western Section. Engineers' Club, Albert-square, Manchester. Fri., Nov. 29, 6.45 p.m.

Royal Aeronautical Society

LONDON
"Some Aspects of Refrigeration in Supersonic Aircraft," by E. J. Gabbay. Tues., Nov. 26, 7 p.m.
"Flight-Testing Procedures at Supersonic Speeds," by Wing Commander R. P. Beamont. Graduates' and Students' Section. Wed., Nov. 27, 7.30 p.m.

Royal Meteorological Society

LONDON
"Weather in the Polar Regions," by H. H. Lamb. County Hall, S.E.1. Tues., Nov. 26, 5.30 p.m.

Royal Society

LONDON
Discussion on "Observations of the Russian Artificial Earth Satellite and Their Analysis," opened by Professor H. S. W. Massey. Fri., Nov. 29, 10.30 a.m.

Royal Statistical Society

SHEFFIELD
"Problems of Long-Term Research in Industrial Medicine," by J. R. Ashford. Sheffield Industrial Applications Group. Y.M.C.A., 49 Fargate, Sheffield, 1. Thurs., Nov. 28, 7 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"The Habershon Planetary Mill," with film, by R. D. R. Habershon. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Nov. 26, 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Mechanism of the Formation of Banded Structures in Steel," by Professor Paul Bastien. Hatfield Memorial Lecture. Frith Hall, The University, Sheffield. Thurs., Nov. 28, 6.30 p.m. (Tickets from the Registrar, The University, Sheffield 10.)

Society of Instrument Technology

LONDON
"Automatic Control and Instrumentation Applied to Air Conditioning," by D. H. Powell. Manson House, 26 Portland-place, W.1. Tues., Nov. 26, 7 p.m.*
CARDIFF
"Method Study as Applied to Instrument Maintenance," by D. L. Smith. South Wales Section. Cardiff College of Technology, Cardiff. Wed., Nov. 27, 6.45 p.m.
GLASGOW
"Air-Operated Controllers," by H. Wigman. Scottish Section. Scottish Building Centre, 425 Sauchiehall-street, Glasgow. Fri., Nov. 29, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Presidential Address, by Sir Harold Hartley. Newcastle Section. King's College, Stephenson Building, Newcastle-upon-Tyne. Thurs., Nov. 28, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. (Midland 1914.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineering Metrology Association, Northampton Polytechnic, St. John-street, London, E.C.1. (CLErkenwell 1662.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Packaging. Apply to Mr. H. Williams, 80 Lancaster-avenue, London, S.E.27. (GIPsy Hill 4859.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw-road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 196 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Non-Destructive Testing Society of Great Britain, 2 Tomswood-terrace, Barkingside, Essex. (HAInault 5488.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Plastics Institute, 6 Manville-place, London, W.1. (WELbeck 5439.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield, 10. (Sheffield 62144.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's-square, Sheffield 1. (Sheffield 24071.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

In Parliament

TAXING TECHNICAL DEVICES

One of the first members in the House of Commons to secure the right to initiate an adjournment debate in the new session was Mr. Arthur Palmer, Labour Co-operative member for Cleveland, who made use of his opportunity to draw attention to the detrimental effect which purchase tax has upon the introduction of many types of new apparatus.

He considered that technical innovations with an export future, such as the device known as the heat pump had, should be encouraged by the taxation system and not stifled by it at birth. A special point in favour of this particular device was that it helped to conserve energy, supplies of which were so scarce in Britain and yet so essential to her continuance as an industrial nation.

The idea had first been worked out by Lord Kelvin, but had then been lost sight of until 1929, when Mr. T. G. N. Haldane had read a paper on the subject before the Institution of Electrical Engineers, pointing out that the device had many current possibilities, owing to modern refrigeration techniques.* The heat pump could be best understood, in fact, as a sort of hot first cousin to the refrigerator. Its aim was to make things warmer, by extracting heat from some low-temperature source, such as the soil, a lake, or a stream, using the heat thus obtained for any convenient purpose, either directly or indirectly.

* "The Heat Pump," Jnl. I.E.E., vol. 68, page 666 (1930).

HEAT PUMPS IN THE U.S.

Although the pump's motor was, of course, driven by electricity, the energy extracted from the external source was much greater than that so consumed and, Mr. Palmer continued, he understood that, for every unit used by the motor, an equivalent of four units in heat form was obtained. The device was thoroughly practical, a special installation had been in use in Norwich for about six years, and many thousands were being installed in the United States every year.

An enterprising British firm had now developed the idea in an extremely compact form, by which it was possible to obtain many gallons of hot water for domestic purposes, while, at the same time, providing considerable refrigeration. He imagined that many British electrical manufacturers would be anxious to consider the export prospects of the heat pump if it were financially practicable to develop the device. Taxation, however, stood in the way of its large-scale development. It could be demonstrated that the heat pump, used in connection with the average domestic installation, would save about one ton of coal a year, compared with the consumption of solid fuel by the same appliance. But the solid-fuel installation of approved type bore no purchase tax, while the more efficient heat pump was taxed at 60 per cent.

PURCHASE TAX HANDICAP

Replying on behalf of the Government, Mr. J. Enoch Powell, the Financial Secretary to the Treasury, pointed out that there were a number of general considerations which might properly be put to the House. The relevant provision under which the heat pump attracted purchase tax was that which applied the tax to appliances and apparatus of a kind used for domestic purposes, including cooking, heating and refrigerating appliances designed for operation by electricity or gas.

Mr. Palmer had suggested that the heat pump deserved encouragement as a new development, that it had important export potentialities, and that it was valuable as a means of conserving fuel. An attempt to apply any of these three criteria as a means of distinguishing between different appliances of the same class for purposes of purchase tax would be quite impracticable and would lead to anomalies and distinctions which no one could defend, even if such distinctions could be administered. If it were conceded that it was desirable for new appliances to be exempted from purchase tax, how could it be determined when they ceased to be new? At what point could articles be considered to have established themselves sufficiently to attract tax?

Export possibilities, too, were a matter of degree. Most articles in the group referred to had export potentialities. As to treating the heat pump preferentially on account of its special heat-conserving aspects, there was no distinction for purchase-tax purposes between the more and the less efficient solid-fuel appliances. Most electric heating and refrigerating appliances could claim a varying degree of efficiency compared with other forms in their conservation of fuel and it would be quite impractical to arrange a kind of tariff of purchase-tax liability, varied according to such efficiency.

FUEL-SAVING IN INDUSTRY

Asked by Sir William Anstruther-Gray, Bt. (Conservative) to make a statement on the progress made in respect of the Government's campaign for fuel-saving in industry, Mr. David Renton, the Parliamentary Secretary to the Ministry of Power, said that the National Industrial Fuel Efficiency Service had confirmed that the target set by Sir Harry Pilkington's committee was a reasonable one. The third progress survey recently published by the Service, which was one of the principal bodies concerned with the problem of fuel efficiency, showed that satisfactory progress was being made towards reaching that target.

Mr. Renton added that Sir Harry's target was an indication of the fuel savings which could probably be achieved rather than an estimate of the real scope for savings, which might, of course, be much greater. With the efforts of all concerned, aided by the advice of N.I.F.E.S and others, he hoped that the target would not only be achieved but exceeded.

EXPORT OF ATOMIC REACTORS

Replying to questions by Mr. Roy Mason (Labour) as to the extent to which Britain had been able to make progress in the development of a package atomic reactor for export purposes, Mr. Reginald Maudling, the Paymaster-General, said that recent studies had suggested that the Calder Hall type of reactor should be capable of modification to produce electricity at a competitive price from small stations of about 20 to 30 MW capacity.

In addition, a number of other reactor systems were being investigated, which might be suitable for electricity generation in smaller power stations. Two United Kingdom firms had marketing rights for small power reactors of United States design. Manufacturers in the United Kingdom had received a number of inquiries and were actively exploring possible markets for the types of reactor which they could offer. He fully realised that there existed a vast market and that Britain should do her utmost to advertise what she could do, and endeavour to attract the attention of the many nations that so badly needed this source of power.

Research was continuing into the potentialities of a very large number of reactors of different types: pressurised water, heavy water gas-cooled, organic-liquid moderated, and so on.

Asked by Mr. Arthur Woodburn (Labour) is he were aware that American firms were already booking orders in South America for package reactors and whether British firms were being encouraged to enter this field, Mr. Maudling said that the Government were indeed encouraging British firms in every way. Some of our firms were acting as agents for American reactors but, Mr. Maudling added, he understood that the small reactors under construction for civilian use in the United States were not yet operating. No proof was available, therefore, of their reliability or economy.

British Way of Life

A compliment was paid by Dr. Charles Hill, the Chancellor of the Duchy of Lancaster, to the British information services, which, he told the House, were doing an excellent job in making known the achievements, ideals, and way of life of the British people. At the same time, the measures which were announced by the Government in July last would enable them to do even better (Cmd. 225, H.M.S.O., price 6*d*.). Dr. Hill said, in reply to Mr. Anthony Greenwood (Labour), that the decision to close down the services of the British Broadcasting Corporation to Scandinavia and Portugal had been the subject of a great deal of thought before action had been taken, and he could not hold out any hope of the Government's action being modified.

Recruiting Atomic Energy Staff

The Prime Minister was asked by Mr. Frederick Willey (Labour) whether, on grounds of public policy, he would instruct the heads of Government departments to facilitate the transfer of officers from the Civil Service to the United Kingdom Atomic Energy Authority. Mr. Willey stressed the importance of such transfers, having regard to the rapid progress being made in research and development in atomic energy matters. Mr. Harold Macmillan said that heads of departments were already aware that it was the policy of the Government to make such transfers easy. He would be happy to consider any individual cases brought to his notice, but, since the Authority was set up, about 6,000 established Civil Servants had been transferred to its service, some 5,700 officials as part of the original arrrangements and some 300 officials since that time.

Pooling Scientific Knowledge

Mr. Macmillan informed the House that the Government were entirely in favour of international co-operation in the exchange of scientific knowledge in the interests of peace, subject to the need to safeguard national security. Much had been accomplished already in the pooling of such knowledge, as, for example, in connection with the Organisation for European Economic Co-operation and the European Productivity Agency. The Prime Minister told Mr. Hector Hughes (Labour) that he believed that a new impetus would be given to this work of co-operation as a result of his talks with President Eisenhower.

Easing Route to Channel Ports

Further details were sought by Mr. Barnett Janner (Labour) of the new motor road to the Channel ports, the construction of which had been announced by the Minister of Transport and Civil Aviation on October 18. He was informed by Mr. Harold Watkinson that he had been referring primarily to the Medway towns by-pass, a motorway about 25 miles long, which would provide a greatly improved route between London and Dover, as well as to North Kent. The A20 route to Folkestone, which already embodied the new Ashford by-pass, would also be much improved by the construction of the Maidstone by-pass.

Technical Education Statistics

A series of questions by Mr. Austen Albu (Labour) on educational matters produced the information from Mr. Geoffrey Lloyd, the Minister of Education, that 454 full-time courses in advanced science and technology were held at technical colleges in England and Wales during the session 1955-56, the latest period for which particulars are at present available. Part-time day courses during the same session numbered 1,509.

There were, the Minister said, 37 courses now being conducted for the Diploma in Technology at a total of eleven colleges. Students in their first year of study for these courses at colleges in England and Wales numbered 532, and there were 291 second-year students.

The Human Element

Long-Term Wage Contracts

Lord Chandos' suggestion last week on television that peace on wage demands should be obtained by offering labour a 2½ per cent. increase per annum in wages is an old friend in new guise. It is a form of long-term wage contract which is already accepted by some unions and managements in the United States. So far it seems to have made little headway in this country. Its drawback is its appearance of being rather near some form of a national wages policy and to eliminate to some extent collective bargaining.

The idea has its attractions however. If labour could be persuaded to take a foreseeable slice of increased production a degree of stability would certainly be achieved. The fact is, however, that not all trade union negotiators would admit that they are only after a certain proportion of increased output from year to year. Some admit that they are after a much more drastic levelling than that, in effect a further re-distribution of income. If the more level-headed leaders in the unions were to accept the idea of a steady 2½ per cent. they might lose out to the hotheads. The annual round of collective bargaining has its vices—but it also has certain virtues. The responsible union leaders get a chance to show their zeal for their members' interests.

Pointers for Suggestion Schemes

In many companies, suggestion schemes from operatives have had an unhappy history. In the latest issue (autumn, 1957, No. 27), of *European Productivity*, published by the European Productivity Agency in Paris, a successful case history from Monsanto Chemicals (Aust.) Limited is reviewed. On the whole the scheme has worked well in the opinion of managers, foremen and operatives although there has been a sizeable group of dissidents from this view. The main ingredients of success seem to have been detailed planning and effective communication. Detailed planning in advance involves making it quite clear that the adoption of suggestions is in the hands of managers of departments, not basically in the hands of the committee which handles the suggestions, although they assess rewards once the manager has said that a suggestion is practical. It has also been found desirable to make it quite clear what the range of awards is. The main complaint in this successful scheme has been that the committee takes too long to adjudicate but this has not been sufficient to jeopardise its continuation.

Openings for Spies

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Garbage—Use and Abuse

Applied engineering and applied economics do not always make good travelling companions, but it has happened on garbage disposal in Germany. The account in *The Times* last week of the way in which the German dustman (no garbage disposal officer this) has maintained the dignity of his calling in the early days of the atomic age with the aid of mechanised refuse collection and disposal is an outstanding example of how dignity in one's calling can be preserved. Time was when dustmen were ranked as the lowest of unskilled workers when those who write textbooks wanted to illustrate certain economic features about unskilled, unattractive work. The Germans have found the solution to the problem of getting more dustmen not by paying very high wages but by giving them good equipment and taking the drudgery out of their work. The German dustman is now a uniformed, tidy and even somewhat resplendent figure with his mechanised dustcart.

The Germans clearly have the right answer in their solution in terms of human dignity. If too much reliance is put on the gain to be made out of garbage it can become merely a racket. This has happened in the United States where a Senate investigating committee is about to look into racketeering in garbage collection. In some areas apparently those who do not pay the racketeer's fee have to live with their dustbins unemptied indefinitely.

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The Human Element

Long-Term Wage Contracts

Lord Chandos' suggestion last week on television that peace on wage demands should be obtained by offering labour a 2½ per cent. increase per annum in wages is an old friend in new guise. It is a form of long-term wage contract which is already accepted by some unions and managements in the United States. So far it seems to have made little headway in this country. Its drawback is its appearance of being rather near some form of a national wages policy and to eliminate to some extent collective bargaining.

The idea has its attractions however. If labour could be persuaded to take a foreseeable slice of increased production a degree of stability would certainly be achieved. The fact is, however, that not all trade union negotiators would admit that they are only after a certain proportion of increased output from year to year. Some admit that they are after a much more drastic levelling than that, in effect a further re-distribution of income. If the more level-headed leaders in the unions were to accept the idea of a steady 2½ per cent. they might lose out to the hotheads. The annual round of collective bargaining has its vices—but it also has certain virtues. The responsible union leaders get a chance to show their zeal for their members' interests.

Pointers for Suggestion Schemes

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have you a coupling problem?

Errors in the alignment of connected shafts are, generally speaking, unavoidable. Even when exceptionally favourable conditions do permit of perfect alignment in the beginning, working loads must eventually cause misalignment. Wear of bearings and vibration are two certain factors which contribute to throwing connected shafts out of true, and even changes of temperature may vary alignments.

Moss Geared Couplings will be found to be the perfect solution to this problem of retaining efficient operation. Intensive research has enabled us to design a Coupling which not only balances alignment errors, but also permits free lateral float to the connected shafts, thus increasing enormously the life of connected machinery.

Moss Gear Couplings are available in a large range of sizes and our illustration shows a rolling mill main drive coupling connecting 20" diameter shafts.

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